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Logistics Control and Information Support (LOCIS)

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Final Report for the Period September 1999 to September 2004

Approved for public release; distribution is unlimited.

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NOTICES

TECHNICAL REVIEW AND APPROVAL

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

FOR THE COMMANDER

//SIGNED//

CURTIS J. PAPKE, Colonel, USAF
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14. ABSTRACT
This technical report contains the results of the Air Force Logistics Control and Information Support (LOCIS) project. The LOCIS objective was to perform logistics research and development in a series of spirals that concentrated on information technologies applied to wing level decision makers and to support the Agile Combat Support and the Air Expeditionary Force. More specifically, the objective was to explore, develop and integrate information technologies that automatically access critical information; display clear and concise information; help the user solve difficult problems by suggesting alternative courses of action; and autonomously take action that benefits the user. These objectives were implemented through the following technological areas: Information Fusion, Proactive Decision Support, and Dynamic User Interface. In summary, an effective LOCIS system will provide multiple benefits including more timely information, minimized search time, reduced data interpretation, predictive simulations, and dynamic re-planning.

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Preface

This technical report contains the results of the Air Force Logistics Control and Information Support (LOCIS) project. This work was executed under the Air Force Research Laboratories contract F33615-99-C-6010. The work described in this report was performed from 15 September 1999 through 30 September 2004. The objective of this task was to perform logistics research and development in a series of spirals that concentrated on information technologies applied to wing level decision makers and to support the Agile Combat Support and the Air Expeditionary Force. More specifically, the objective was to explore, develop and integrate information technologies that automatically access critical information; display clear and concise information; help the user solve difficult problems by suggesting alternative courses of action; and autonomously take action that benefits the user. These objectives were implemented through the following technological areas: Information Fusion, Proactive Decision Support, and Dynamic User Interface. Also included in this report is a paper describing the initial effort to measure Situation Awareness (SA) in the context of logistics command and control (see Appendix E). LOCIS is a prototype decision aid intended to allow a maintenance supervisor to perform his/her job more quickly without any loss of SA.

The principal investigators for this effort included Mr. Chris Curtis, Capt. Kelly Vinson and Lt. David Lemery from AFRL, Mr. Gary Hardenburg, Mr. Clark Moskop and Mr. John Potts from BAE Systems, Mr. Rick Iannacchione and Ms. Deb Fannon from Kelley's Logistics Support Systems, Dr. Deborah Mitta from Georgia Tech Research Institute and Ms. LaDonna Schneller and Mr. Rob Roy from Decision Sciences Inc.

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Acronyms

Acronym	Definition
AFC2ISRC	Air Force Command and Control Intelligence Surveillance Reconnaissance Center
ACC	Air Combat Command
AEF	Air Expeditionary Force
AFB	Air Force Base
AFRL/HEAL	Air Force Research Laboratory/Logistics Readiness Branch
ASRT	Aircraft Status Reporting Tool
C2DB	Command and Control Database
CAMS	Core Automated Maintenance System
CAS-A	Combat Ammunition System-Ammunition Control Point
CBA	Cost Benefit Analysis
CCDT	CAMS Connectivity Development Tool
CDR	Critical Design Review
CDRL	Contract Data Requirements List
COTS	Commercial-off-the-Shelf
DARPA	Defense Advanced Research Project Agency
DSI	Decision Sciences, Inc.
EDD	Estimated Delivery Date
EDW	Electronic Data Warehouse
EMOC	Enhanced Maintenance Operation Capability
ESC	Electronic Systems Command
ETIC	Estimated Time in Completion
FMC	Fully Mission Capable
FW	Fighter Wing
GCSS-AF	Global Combat Support System Integration Framework for the USAF
GOTS	Government-off-the-Shelf
GTRI	Georgia Tech Research Institute
GUI	Graphical User Interface
HF	Human Factors
HOF	Health of Fleet
IPT	Integrated Product Team
J2EE	Java 2 Enterprise Edition
JCN	Job Control Number
KLSS	Kelley Logistics Support System
LG	Logistics Group Commander

Acronym	Definition
LOA	Logistics Officer's Association
LOCIS	Logistics Control and Information Support
LOGTIE	Logistics Technology Integration Environment
LUG	LOCIS User Group
MDS	Mission Design Series
MICAP	Mission Capability
MOC	Maintenance Operations Center
MXG	Maintenance Group Commander
NTIS	National Technical Information Service
NMC	Not Mission Capable
ODS	Operational Data Store
OG	Operational Group Commander
PA	Public Affairs
PDA	Personal Digital Assistant
PDR	Preliminary Design Review
PMC	Partially Mission Capable
PPofE	Program Plan of Execution
R&D	Research and Development
SIMFORCE	Scaleable Integration Model for Objective Resource Capability Evaluations
SLAP	Senior Logistics Advisory Panel
SRS	System Requirements Specification
UDRI	University of Dayton Research Institute
UML	Unified Modeling Language
URL	Universal Resource Locator
USAF	United States Air Force
WAT	Warnings and Alerts Thresholds
WinMASS	MICAP Asset Sourcing System for Windows Operating System
WOC	Wing Operations Center
WUC	Work Unit Code

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1 Overview

This Final Report documents the results of the Logistics Control and Information Support (LOCIS) Research and Development program. LOCIS was a 42 month project, sponsored by the Air Force Research Laboratory at Wright Patterson Air Force Base (AFB), supported by the Air Force Command and Control Intelligence Surveillance Reconnaissance Center (AFC2ISRC) at Langley AFB. Other stakeholders included ACC/LGX, AFSOC/LG, and SSG/IL. BAE Systems was the prime contractor with key support provided by Kelley's Logistics Support System (KLSS), Georgia Tech Research Institute (GTRI) and Decision Sciences Inc. (DSI).

The program began in September 1999 and included demonstrations each year through Spiral 3. Figure 1 shows the spiral model of the 42-month program, which began the first year focused on the Operations Group Commander (OG), the Logistics Group Commander (LG) and their associated staff. Subsequent years included lower levels of command, such as the production supervisor and other areas of concern, such as munitions. Each spiral also added additional capabilities, such as in Spiral 3 when deployment planning and munitions tracking were incorporated. The results of each yearly spiral fed into the next year's research through lessons learned and comments from users and those present at the many demonstrations.

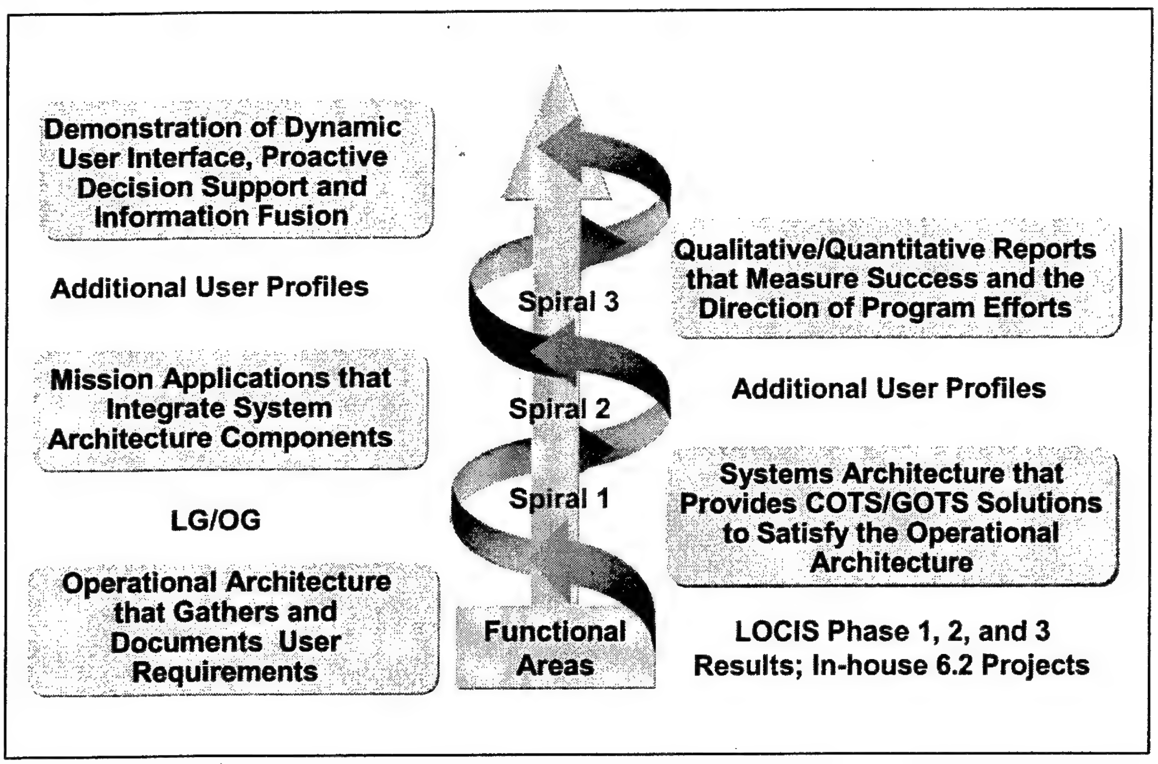


Figure 1. LOCIS Spiral Model

Each spiral also contained a series of quantitative and qualitative reports that assessed the success of the specific capabilities demonstrated that year and performed a cost benefit analysis of the specific capabilities. This report contains a summary of each spiral and the overall results of the quantitative and qualitative analysis with specific emphasis on the final spiral.

2 Objective

The LOCIS program objective was to perform logistics research and development in a series of spirals that concentrated on information technologies applied to wing level decision makers and to support the Agile Combat Support and the Air Expeditionary Force. More specifically, the objective was to explore, develop and integrate information technologies that automatically access critical information; display clear and concise information; help the user solve difficult problems by suggesting alternative courses of action; and autonomously take action that benefits the user. These objectives were implemented through the following technological areas: Information Fusion, Proactive Decision Support, and Dynamic User Interface.

3 Goals and Benefits

The following is a list of exit criteria for the LOCIS program:

a. Enable proactive decision making by commanders/supervisors.

b. Reduce the time to re-plan during a crisis-action contingency.

c. Reduce staff hours to produce capability and historical reports.

d. Reduce time required to assess the impact of operational changes on wing/unit level logistics.

e. Provide improved assessment of the logistics capability of units to support tasked combat missions.

In addition, the following is a list of the primary goals for LOCIS that all fall within the support of the Air Expeditionary Forces, Agile Combat Support and Joint Vision 2020:

a. Push timely information to logistics personnel.

b. Minimize time searching for the "right" information.

c. Reduce the need to interpret data.

d. Create customized reports and presentations.

e. Predict situations and give users enough time to prevent problems.

f. Analyze alternative courses of action through easy-to-use "what if" simulations.

g. Support dynamic re-planning using real-time thresholds and alerts.

h. Feed better information to theater-level command and control systems.

In summary, an effective LOCIS system will provide multiple benefits including more timely information, minimized search time, reduced data interpretation, predictive simulations, and dynamic re-planning. Currently, because of personnel-intensive tasks, many decisions made by USAF commanders require multiple people researching and pulling data from a variety of sources in order to supply the required information for decision-making. For daily standup meetings, for example, the commander may have a staff of people preparing presentation charts with data that is several hours old by the time the meeting is conducted. Through LOCIS, this picture is drastically different. Based on user preferences, in day-to-day situations as well as during time critical situations, LOCIS pushes accurate and timely information to the user. Thresholds can be set on a variety of critical data elements that, when surpassed, cause new views of critical information to be presented to the user. LOCIS also allows the user to change parameters and run scenarios to predict 30 day, 60 day and other future look-ahead simulations. In addition, at the touch of a button, information is disseminated and/or captured for reviewing at the next standup briefing. All combined, LOCIS will feed better information to the warfighter.

4 Background

With the changes that have occurred in both the geopolitical environment and the United States Air Force, operational units are challenged now more than ever to maximize use of all available resources, while maintaining a very demanding operational and deployment tempo. Logistics personnel have discovered that the concept of '*Do more with less*' has evolved from an initial draw down philosophy to a permanent concept of operations. As a result, mission success depends upon logistics now more than ever. Despite the rapid changes in logistics requirements and constraints, the supporting legacy information systems have remained somewhat stagnant, and, as a result, are less effective in supporting senior logistics decision makers and field personnel.

The downsizing of the force and the reduced funding and sparing for parts, combined with drastic changes in world power, have led to a requirement for even greater control over available resources within the wing. Current management information systems for wing-level logistics are slow and manpower-intensive, often requiring specialists for interpretation of data before decision makers can make quick and accurate logistics decisions. Figure 2 identifies the LOCIS vision to automate and make accessible key information to decision makers.

LOCIS efforts concentrate on the direct sortie production logistics functions of aircraft maintenance, munitions, and supply (operations support). These will be referred to hereinafter as first tier or direct sortie production functions as shown in Figure 3. Second tier functions include such traditional logistics support functions as: fuel, supply (base support), transportation, logistics plans, and contracting. The remaining (third tier) support functions are termed ancillary and include: civil engineering, disaster preparedness/air base operability, services, communications, security, personnel/manpower, medical, operations, weather, and intelligence. Through expansion, it was intended that LOCIS would eventually cover the other tiers of information, giving the logistics decision makers the complete set of data for making decisions.

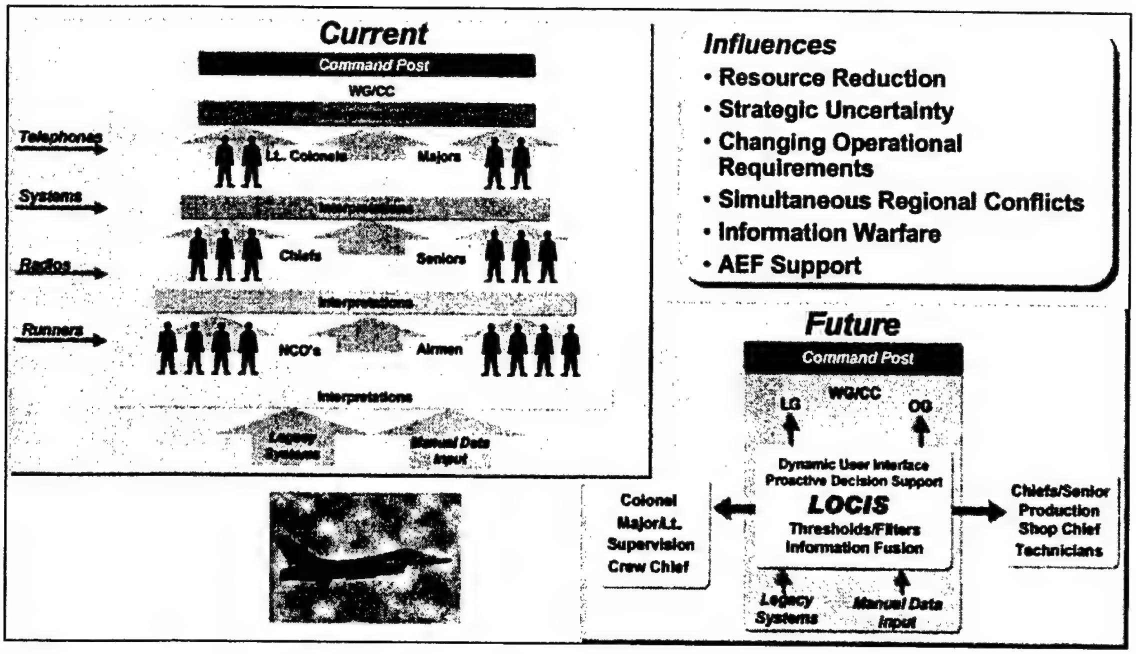


Figure 2. LOCIS Vision

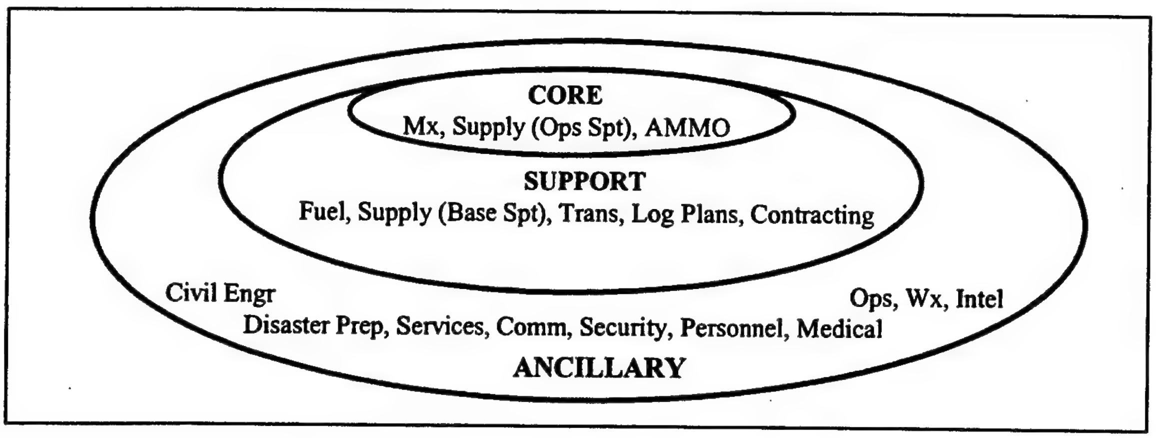


Figure 3. Logistics Functional Area Tiers

LOCIS Research and Development included a series of activities including a Feasibility Study and Requirements Definition before the complete R&D program began with three spirals. The following section summarizes the feasibility study, requirement definition, Spiral 1 and Spiral 2.

4.1 Phase I – LOCIS Feasibility Study

To test the soundness of the concept, AFRL initiated a Feasibility Study in March 1995 to determine whether there is a need for improved accuracy and timeliness in the flow of logistics information to the wing-level command and control processes. One of the first tasks performed during the Feasibility Study was to document the high-level goals and processes envisioned by Laboratory personnel. This was done via a facilitated session to document the LOCIS vision.

The facilitated session results identified the following as LOCIS goals:

a. Increase the accuracy and understandability of information.

b. Identify critical logistics information and control mechanisms necessary to accomplish tasks.

c. Provide real-time information sequenced to support specific events.

d. Maximize the use of current legacy automated systems to obtain logistics information.

e. Increase availability of embedded training at the workstation level.

f. Ensure any solutions support mobilizations.

Based on initial field interviews and observations collected, AFRL determined that there is a significant need for more accurate and timely information for logistics decision makers.

4.2 Phase II – LOCIS Requirements Definition

As the next step, AFRL initiated a Requirements Definition effort in April 1996. The goals identified during the Feasibility Study were re-examined and expanded, generating the following objectives for the Requirements Definition effort.

a. ***Support proactive decision making at squadron and wing levels through the use of automated thresholds, filtering and dissemination techniques*** – LOCIS should ensure that logistics decision makers are provided with better information to manage their responsibilities and ensure that better, more accurate, and less manpower intensive information is provided real-time to the Wing Operations Center (WOC).

b. ***Reduce the need to interpret the logistics information*** – The information provided should not require interpretation by decision makers in the WOC in order for it to be immediately useable by the wing battle staff.

c. ***Provide seamless, easy access to logistics information from legacy systems*** – LOCIS data should also provide a much better, more reliable set of real-time data to feed wing level capability simulations.

d. ***Eliminate manual data collection and reporting*** – LOCIS data should provide a more current and accurate set of information to command and control systems at and above wing level.

During this phase, observations were collected from various user organizations and translated into requirements by subject matter experts and lab personnel. Over 1,800 observations were collected from various logistics users and organizations at the following locations.

a. Air Force Special Operations Command, Hurlburt Field – All logistics functions and Command Post.

b. 3rd Wing, Elmendorf AFB – All logistics functions and Command Post.

c. 1st Fighter Wing, Langley AFB Command Post.

d. 162nd Fighter Squadron, Ohio Air National Guard – Maintenance Officer, Production Supervisor and Expediter.

e. US Transportation Command, Scott AFB – Plans and Analysis (J5).

f. HQ AMC, Scott AFB – XPY, DOO, LGXI, LGA, LGF, LGRC – World Wide Tanker Airlift Command Post.

g. HQ ACC, Langley AFB – All logistics staff functions.

h. 1st Fighter Wing, Langley AFB – All logistics functions.

i. 347th Wing, Moody AFB – 69th & 70th Fighter Squadrons – All Logistics functions.

j. 52nd Fighter Wing, Spangdahlem AB – All Logistics Functions, Wing Vice Commander, Operation Group Commander and Command Post.

k. 86th Airlift Wing, Ramstein AB – Logistics plans and command post.

l. HQ USAFE, Ramstein AB – Logistics staff functions (LGM, LGX, LGT).

m. HQ 17th AF, Sembach AB – All logistics functions.

4.3 LOCIS User Advisory Groups

In addition to the feasibility study, requirements development, and user comments, a Senior Logistics Advisory Panel (SLAP) and LOCIS User Group (LUG) were used extensively in the development spirals of LOCIS.

4.3.1 Senior Logistics Advisory Panel

The SLAP, which includes senior-level Air Force managers and officers/government officials, was formed to provide guidance and direction throughout the LOCIS program. The following were tasks performed by the SLAP:

a. Review and prioritize requirements for each of the three phases of the LOCIS spiral development demonstrations. Provide developers with a list of prioritized requirements from "essential" to "possible follow-on work."

b. Ensure requirements traceability is maintained. All LOCIS requirements must be traceable to actual user needs. Ensure LOCIS interview trips are covering the right warfighters, based on the command.

c. Ensure LOCIS capabilities are built independently of organizational structure. Also, LOCIS must be capable of supporting peacetime, deployed, and all phases of the Air Expeditionary Force (AEF) support efforts from generation through sustainment and re-constitution.

d. Build a transitioning plan for the successful integration of the LOCIS effort into the operational Air Force.

Membership to the SLAP kept consistent representation from the following organizations through the development spirals: ACC/LGX, AFSOC/LG, AMC/LGM, AFLMA, AETC/LG, USAF/ILM, AFC2ISRC/A4 and various wing Maintenance Group Commanders (MXGs). The first meeting of the SLAP occurred to review the Spiral 1 demonstration in October 2000. The final SLAP meeting occurred at the conclusion of Spiral 3 in December 2002. Complete results from this meeting can be found in the Year 3 Operational Architecture Specification.

4.3.2 LOCIS User Group

The LUG consists of personnel representing the roles being supported for each spiral. Spiral 1 roles consisted of the Operational Group Commander (OG), Logistics Group Commander (LG) and their staff; this was expanded in Spiral 2 to include the Senior Maintenance Officer; and in Spiral 3 to include the Maintenance Group Commander (MXG), Aircraft Maintenance Squadron Commander, Maintenance Supervisor, and Aircraft Maintenance Unit Supervisors/ Superintendent. This group provided critical feedback on a screen-by-screen, capability-by-capability basis. The LUG first met in April 2000 and consistently met every few months during critical development periods of each spiral. The last LUG meeting was at the end of Spiral 3 in December 2002. Complete results from the previous LUG meetings can be found in the Operational Architecture document. Summary results can be found in Appendix B of this document.

4.4 LOCIS Spiral 1

The LOCIS program in Spiral 1 leveraged a number of AFRL technologies, commercial companies and USAF collaborators to provide a concise and effective demonstration of LOCIS capabilities. A series of well-timed and well-attended demonstrations helped the user base to understand LOCIS, but more importantly, to envision LOCIS expansion ideas and how LOCIS could help them.

The initial step of the Spiral 1 was to validate the 1800 comments received during the requirements study. This was successfully done with visits to Hurlburt Field, Luke AFB and Langley AFB. Not only were the 1800 comments confirmed, but an additional 700 were added. These over 2500 comments were placed into a database and used to create the 193 LOCIS system requirements that can be found in Appendix C.

The initial design and development of the Spiral 1 software was done using the Unified Modeling Language (UML) and updated in each spiral. Four sets of diagrams were developed to define and document the mission application development process. First, the UML Use Case and Class diagrams were created that provided all the information needed and the relationship of this information based upon the user requirements defined by the operational architecture. Secondly, the Activity and Sequence diagrams were developed which documented and identified the required interaction and flow of each software module in support of the Use Case and Class diagrams. All four sets of UML diagrams were published in the System Requirements Specification document. From these diagrams, each of the software modules were coded and integrated.

In achieving the goals of the mission applications, several commercial companies stepped forward and offered hardware and software support. Of these, Microsoft was the most cooperative by giving several thousand dollars of software for each of the LOCIS servers. In addition, Microsoft attended several of the Spiral 1 LOCIS meetings and held several teleconferences with the team to help guide understanding of the implementation of their tools. Neopoint was also a technology partner. They brought to the table free web phones for analysis, discounts on all purchased web phones and free site surveys for web phone service coverage. Finally, in the area of biometrics, I/O Systems provided free software for their proximity detectors and fingerprint readers.

A series of Spiral 1 demonstrations was held 26-28 September 2000 in the Logistics Technology Integration Environment (LOGTIE) facility at WPAFB. The first demonstration was for the LUG, the second was for the SLAP, and the third was for collaborators including the Defense Advanced Research Project Agency (DARPA), the AEF Battlelab, and other organizations within AFRL. In addition to the final Spiral 1 demonstrations, a subset of the LOCIS demonstration was presented in a private suite at the Logistics Officer's Association (LOA) Conference. Several key USAF logisticians attended the private demonstrations.

Comments received during the demonstrations were positive and reinforced the need to work closely with other programs. Specific programs identified were Global Combat Support System Integration Framework for the USAF (GCSS-AF), Enhanced Maintenance Operation Capability (EMOC), and Air Force Portal, which laid the direction for the future LOCIS spirals.

The success of LOCIS in Spiral 1 was based upon a managed set of collaborations with other organizations. The following is an acknowledgement of those organizations that helped make LOCIS a success in Spiral 1:

a. Air Force Command and Control Intelligent Surveillance Reconnaissance Center
b. Air Force Special Operations Command
c. Electronic Systems Command (ESC)
d. 56th Fighter Wing (FW) – Luke AFB
e. PACAF Interim Command and Control System
f. Enhanced Maintenance Operations Capabilities
g. Air Force Portal

4.5 LOCIS Spiral 2

The success of the Spiral 1 demonstrations and results from the LUG were fed into the Spiral 2 development. In addition, these results and the recommendations by the LOCIS SLAP led to the development of a Block Release of Spiral 1 capabilities at Hurlburt Field. Col. Mueller, AFSOC/LG and a SLAP member, offered Hurlburt Field as a site for the LOCIS Block Release, which also became known as the Hurlburt Field LOCIS Living Lab. The following paragraphs summarize the activity at Hurlburt Field.

4.5.1 Hurlburt Field Living Lab

The Hurlburt Field Block Release created a parallel effort during Spiral 2 by the LOCIS team that included both the creation of a working version of the concepts from Spiral 1 and the creation of new conceptual capabilities for Spiral 2. The Hurlburt Field Block Release was vital to the development of LOCIS since it gave daily warfighter feedback on LOCIS capabilities. LOCIS continues to be used on a daily basis by the MXG leadership at Hurlburt Field.

The Hurlburt Field Block Release included all tasks required to make the conceptual ideas of Spiral 1 into real working capabilities and to link the capabilities to live data, which included interfaces to Hurlburt Field's Command and Control Database (C2DB) and the Mission Capable (MICAP) Asset Sourcing System for Windows Operating System (WinMASS).

The Block Release In-brief was held 5 November 2001 and installation began the next day after Hurlburt Field leadership signed the final Base Communications paperwork. The training of Hurlburt Field users was initiated 26-30 November 2001. The Hurlburt Field User's Manual (document number 1004266) was developed and submitted as a hardcopy as well as on-line through the LOCIS application. In addition, a Hurlburt Field Block Release Administration Plan was delivered to assist administration of LOCIS by users at Hurlburt Field.

The LOCIS Human Factors Integrated Product Team (IPT) led three evaluations of the Hurlburt Field Block Release. The results of the evaluations can be found in Appendix B and were used for planning Spiral 3 activities.

4.5.2 Spiral 2 Demonstration

In conjunction with the development and installation of the Hurlburt Field Living Lab, Spiral 2 development was scheduled to complete with a series of demonstrations, including the LOA conference. During Spiral 2, two key collaboration efforts, Air Force Portal and Point of Maintenance, occurred. Work with Air Force Portal resulted in the users at Hurlburt Field having the option to access LOCIS through the Air Force Portal. Though the original intent was to have a single logon, the Air Force Portal implementation at that time did not allow passing of authentication to another application. The final implementation had LOCIS as a personal link for Air Force Portal users at Hurlburt Field.

The second collaboration was with the Point of Maintenance activity at Hurlburt Field. More specifically, the LOCIS software and documentation were changed to portray modifications to work orders on the flightline made with Point of Maintenance hardware. The demonstration

simulated closing a work order on the flightline, which causes an aircraft icon to change from red to green on the LOCIS display.

The main focus of the Spiral 2 development was to tie to real data. This was accomplished at Hurlburt Field by linking to their local Maintenance Operations Center (MOC) database, C2DB, as well as the WinMASS for Mission Capable (MICAP) data. In addition to the data tie-in, Spiral 2 also improved several of the user interface views and updated the alert/warning capability.

The biggest change in Spiral 2 was the redesign of the architecture from a heavy client distributed system to a thin client Java 2 Enterprise Edition (J2EE) system compliant with the evolving GCSS-AF.

5 LOCIS Development Process and Spiral 3

Throughout the spiral development, the following key areas were the centers of activity: Operational Architecture, System Architecture, Mission Applications, Qualitative/Quantitative Reports, and Demonstrations. The following paragraphs describe the process for each of these areas and the resulting development.

5.1 Operational Architecture

The following steps were used to produce the Operational Architecture for each spiral.

a. Develop Scenario Outline of LOCIS spiral demonstration.
    1. Identify requirements
    2. Critical data
    3. Sources of data

b. Coordinate with Human Factors (HF) for functional prioritization.

c. Determine SLAP and LUG Process.
    1. Identify proper composition based on functionality
    2. Identify and contact members
    3. Identify process for small groups (work with HF team)
    4. Set up schedule
    5. Identify what needs to be posted on website
    6. Determine how to validate information

d. Develop requirements process (see Figure 4).

e. Identify Critical Data, Sources of Data and associated Business Rules.

f. Finalize scenario and document information.

g. Validate scenario and information with SLAP and LUG.

h. Final documentation of Operational Architecture.

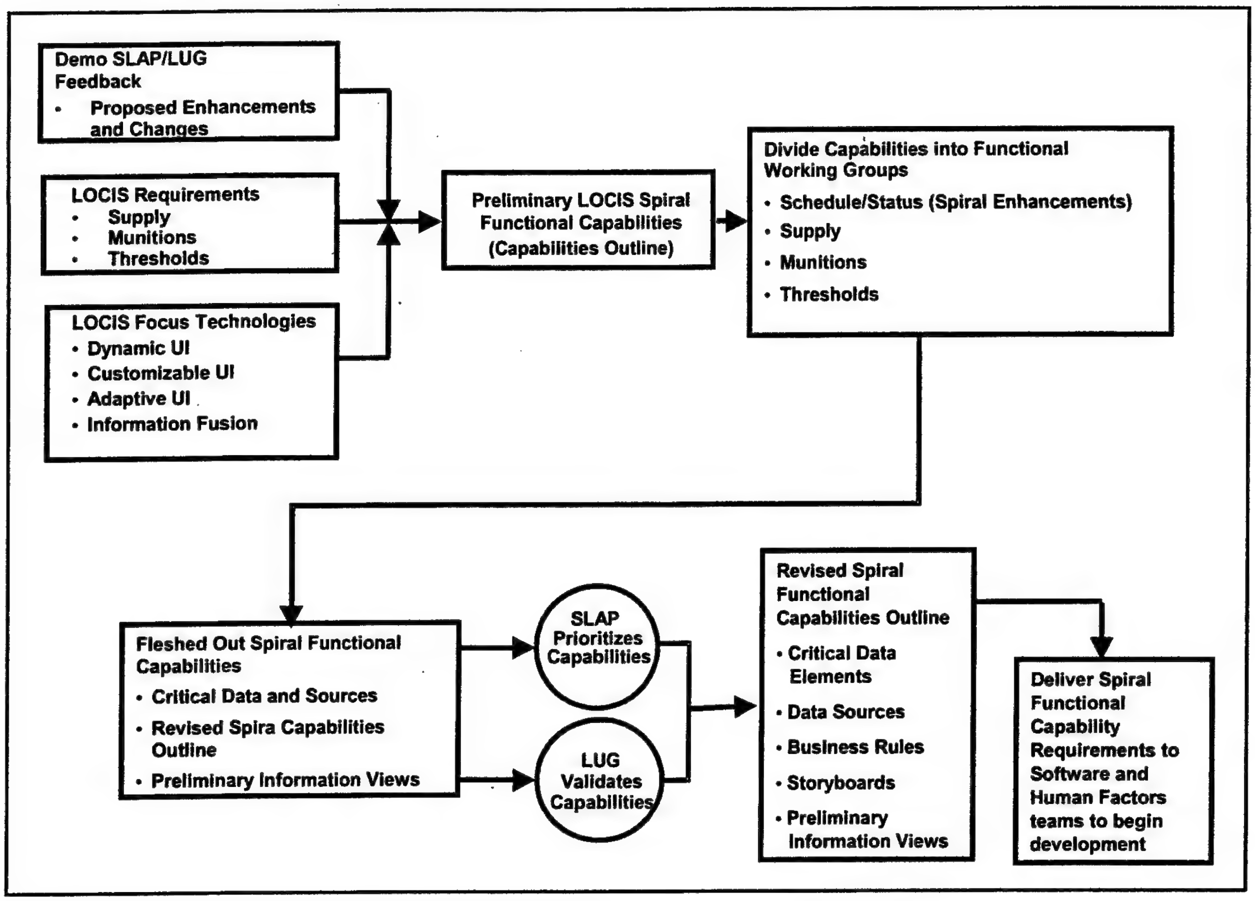


Figure 4. Requirements Process

The LOCIS user profiles included the following personnel: Maintenance Group Commander, Operations Group Commander, Fighter Squadron Maintenance Supervisor and Superintendent.

Through each spiral, a set of functional capabilities was produced. Based upon the success of these capabilities they were moved forward into the next spiral or removed. Figure 5 shows the LOCIS Operational Architecture. Detailed information of the Operational Architecture, including minutes from the SLAP and LUG meetings, can be found in the Spiral 3 Operational Architecture Document (1007830); see Reference Documents. Figure 5 indicates the four key LOCIS data sources: EMOC, Operational Data Store (ODS), Core Automated Maintenance System (CAMS), and Combat Ammunition System – Ammunition Control Point (CAS-A). Agents are used to pull information into the LOCIS repository where it is fused and funneled to the user through profile-based web pages. The Aircraft Status Reporting Tool (ASRT), is a passive data collection tool using FM radios to automatically pull critical information from the base RF radio system.

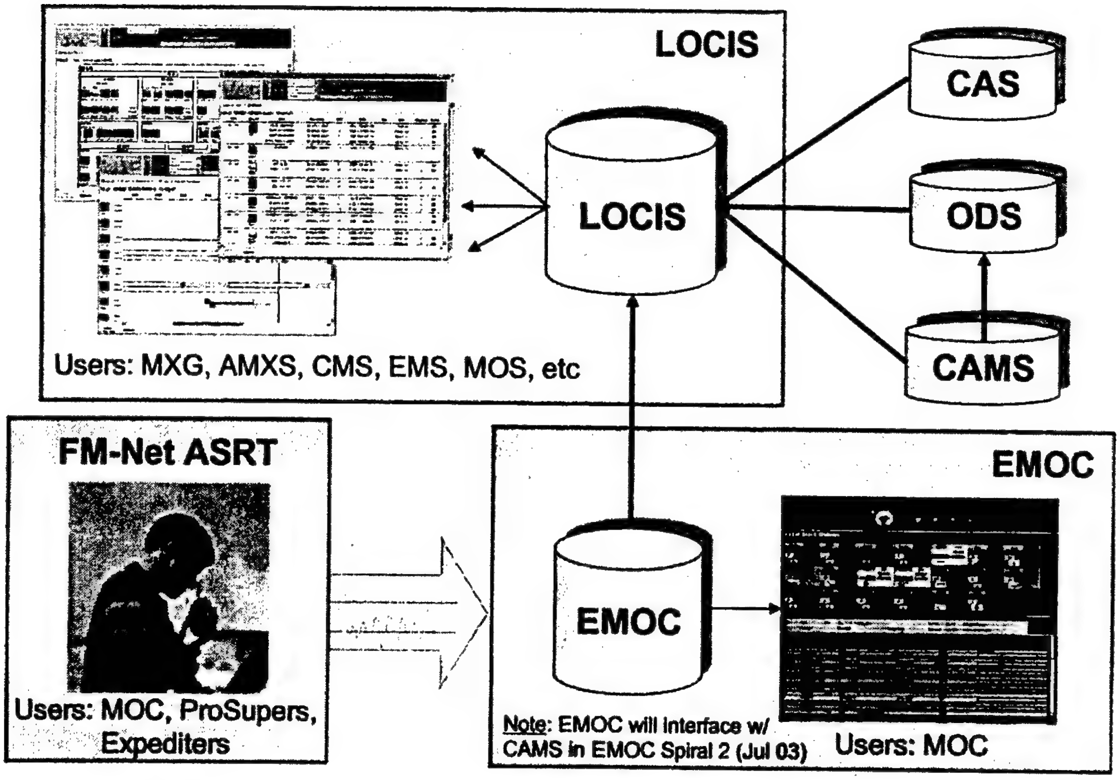


Figure 5. Operational Architecture

In Spiral 3, the following were the key functional capabilities that leveraged the previous two spirals:

a. Develop print/print preview/create reports capabilities.

b. Combined flying schedule at the wing level.

c. Redesign the wing status at-a-glance to reduce or eliminate the need to scroll.

d. Extend Recap to include data prior to the weekend or holiday.

e. Allow Zulu time conversion/display.

f. Add additional timeline customization.

g. Develop 781A view which displays all open discrepancies by tail number.

h. Add additional critical data to the roll-over on the A/C icon.

i. Address several Graphical User Interface (GUI) issues including resize of screen and memory of column size and location.

j. Add additional information to the drill down, additional data to the MICAP screens and additional data to the supply screens.

k. Add a weekly calendar inspection view.

l. Add the ability to see the status of line numbers and be notified when they are behind in the launch sequence.

m. Develop a top level geographical layout of a base/aircraft status.

n. Add capability to drill down on scheduled and actual activity on the flying schedule.

o. Add an option for a single panel workspace with the current dual and quad options.

p. Develop a capability to create thresholds on launch sequence, task requirements, and munitions availability.

q. Add capability to enhance decision support functions to include forecasting capabilities.

r. Add capability to forecast munitions availability based on a given tasking at a specific deployment location.

s. Develop 781-K View which displays all delayed/deferred discrepancies by tail number.

5.2 System Architecture

The system architecture was the study, analysis and design of Commercial-off-the-Shelf (COTS) and Government-off-the-Shelf (GOTS) products and the architecture created by these products that satisfied the operational architecture's requirements.

The most important product from the system architecture was the System Requirements Specification (SRS), which was the guiding document for the spiral demonstration development.

During Spiral 2, the architecture from Spiral 1 was completely redesigned. The Spiral 1 architecture, though distributed and web-based, involved a thick client requiring multiple Microsoft products including Microsoft Excel, Outlook and Digital Dashboard. This architecture was not compliant with the evolving GCSS-AF, which began to move to the emerging J2EE. During Spiral 3, this conversion to J2EE was completed. Also in Spiral 3, the concept of web services was implemented through a combination of J2EE and Microsoft.Net Web Services. This created an open environment capable of supporting J2EE and Microsoft technologies. The software design is covered in more detail in the Mission Application section of this document.

The system architecture was also responsible for identifying any additional system hardware and software required for the demonstrations. A series of studies during each spiral was performed. This included data mining, biometrics and wireless studies in Spiral 1; messaging, portal, pivot table/snapshot/links, information fusion, data mining, trend analysis, simulation and dynamic rescheduling studies in Spiral 2; and proactive decision support, bioscience, agents, data manipulation, architecture and framework studies in Spiral 3. More specifically, more than 200 slides were developed for the Spiral 3 Preliminary Design Review (PDR) that assessed the usability and availability of technologies for LOCIS. The studies and associated information can be found in the specific spiral PDR/Critical Design Review (CDR) slides as well as the Final Report for each spiral. Figure 6 depicts the core technologies that have been the theme of each LOCIS spiral.

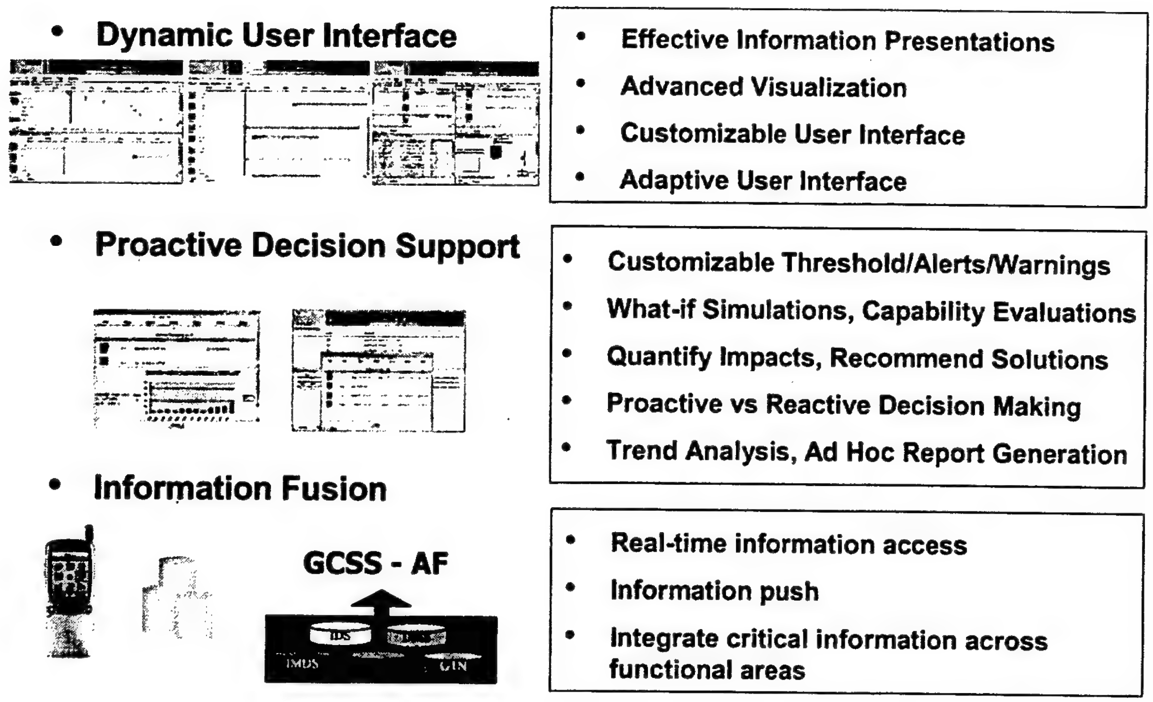


Figure 6. LOCIS Core Technologies

5.2.1 System Capabilities

The following paragraphs further describe the major system capabilities to be developed, tested and fielded as LOCIS components.

5.2.1.1 Data Fusion Capability

LOCIS fuses information from multiple sources in order to provide a complete decision making capability. Because of this, LOCIS itself is not a data store (neither retaining nor storing information). LOCIS pulls from multiple data systems to fuse elements and map them to specific decision support views within LOCIS based upon the user profile. This fusion capability will, among other things, filter data, trigger warnings or alerts based upon new values, and update the LOCIS data repository appropriately. Technologies involved in this area include data fusion, access to data warehouses, filtering and agents.

Therefore, LOCIS is dependent on the current USAF information systems for access to data. Specifically, LOCIS is required to reside within the evolving GCSS-AF and fuse data from a variety of sources, such as EMOC, CAMS and CAS-A.

5.2.1.2 Proactive Decision Support

LOCIS provides proactive decision support capabilities in a users' environment, which may include a wall display, desktop, Personal Digital Assistant (PDA), or cell phone. These capabilities include (1) a "what-if" predictive capability, (2) a best tail and health of fleet advisory tool that is based on rules and simulation, (3) munitions tracking against schedule

requirements and (4) personal alerts and warnings of key indicators that are set to individual thresholds. These tools allow the user to make better decisions regarding current situations, but, more importantly, allow the user to better prepare and better assess future situations.

5.2.1.3 Dynamic User Interface

The key to the presentation and, ultimately, the support for making decisions is the dynamic user interface. This interface is customizable by each user through the use of web page options, such as data refresh, timeline extensions and icon symbols. Once the user tailors these views, the user can then combine them into personalized workspaces that can be quickly reviewed at any time. In this way, the user can very quickly assess what has happened, what is happening and the key areas where decisions are required.

In addition, these workspaces can be individually tied to specific alerts and warnings such that when an event occurs, key workspaces are automatically presented. This capability saves time in searching and interpreting information during critical periods. These interface features are based on information being pushed to the user, which in turn is based on unique user preferences. Technologies involved with developing this intelligent user interface include push technology, agents, and advanced visualization techniques.

5.2.2 System Interfaces

In fulfilling mission requirements, LOCIS will interface with the following systems, receiving data elements as indicated:

CAMS	Core Automated Maintenance System
CAS-A	Combat Ammunition System-Ammunition Control Point
EMOC	Enhanced Maintenance Operation Capability
ODS	Operational Data Store
C2DB	Hurlburt Field Command & Control Database

Note: All databases accessed by LOCIS are import only—LOCIS does not store the data for historical use. LOCIS is not a data store.

5.3 Mission Application Development and Integration

The software development and integration of the three key technical areas of LOCIS (information fusion, decision support, and dynamic user interface) occurred within the mission application development and integration.

To support the development and delivery of the Mission Application, a series of deliverables were created and submitted to the LOCIS customer. The following documents should be referenced for more detailed information regarding the Mission Application: Demonstration Plan, Software Product Specification, Training/Administrator's Plan, Software End Item, and Software Version Description—see Reference Documents.

Figure 7 identifies the software capabilities as they evolved throughout the three spirals. At the top (in parentheses) is the main emphasis of each spiral. As shown, the proactive decision support and the dynamic user interface were the key development areas in Spiral 1. Spiral 2 upgraded the user interface and fused real data from Hurlburt Field data sources, but did not add much technology in the decision support area. Spiral 3 focused on standardizing data access from USAF data sources and adding munitions capability to the system.

	Spiral 1 (Maintenance)	Spiral 2 (Supply)	Spiral 3 (Munitions)
Dynamic User I/F	• Web-enabled • Client Server • Thick Client • Auto status reports	• Web-centric • Thin Client • Customized Interface • Workspace Wizard	• Adaptive Interface • Automatic/Ad Hoc Report Generator
Proactive Decision Support	• Simulation • Concept Warnings/Alerts • Integrated A/C Status & Schedules • Pivot Table Concept • Triggers	• Robust and Concept Warnings/Alerts	• Automated Scheduling Recommendations • Capability Assessments • Extended Agent Framework
Information Fusion	• Simulated data	• Agent Monitoring and Feed Data • 16 SOW MOC C2DB: Maintenance and Flying Schedule Data • WinMASS: MICAP status	• Agent Monitoring and Data Feed • ODS & CAMS data access • EMOC data access

Figure 7. Development of Spiral Software Capabilities

The key focus of the Spiral 3 Mission Application development was the modularization and standardization of the software. In particular, the goal was to create a more robust LOCIS that could also be installed from base to base economically. The key to this was the development of a more modular architecture as shown in Figure 8. This figure highlights the Java servelets and applets that were used by the web server to produce the thin client interface. This architecture conforms to the evolving GCSS-AF Integration Framework. Figure 8 also depicts the COTS tools, Formula One and JRules, for the report generation and advisory tool capability. Additionally, Figure 8 defines the internal warning and alerts thresholds (WAT), housekeeping, preference, message and trigger managers that manipulate the data received from the variety of data sources.

A number of studies were performed with results being presented at the Spiral 3 PDR and CDR. These studies included the following: report generation tools, rule-based tools, web servers and databases. Final study results chose Formula One for report generation, JRules for rule-based tools, BEA Weblogic as the web server and Oracle as the database. The main driver for the Oracle choice was the USAF license—Spiral 1 and 2 used Microsoft SQL Server, but for future deployment economics it was decided that Oracle was a better choice.

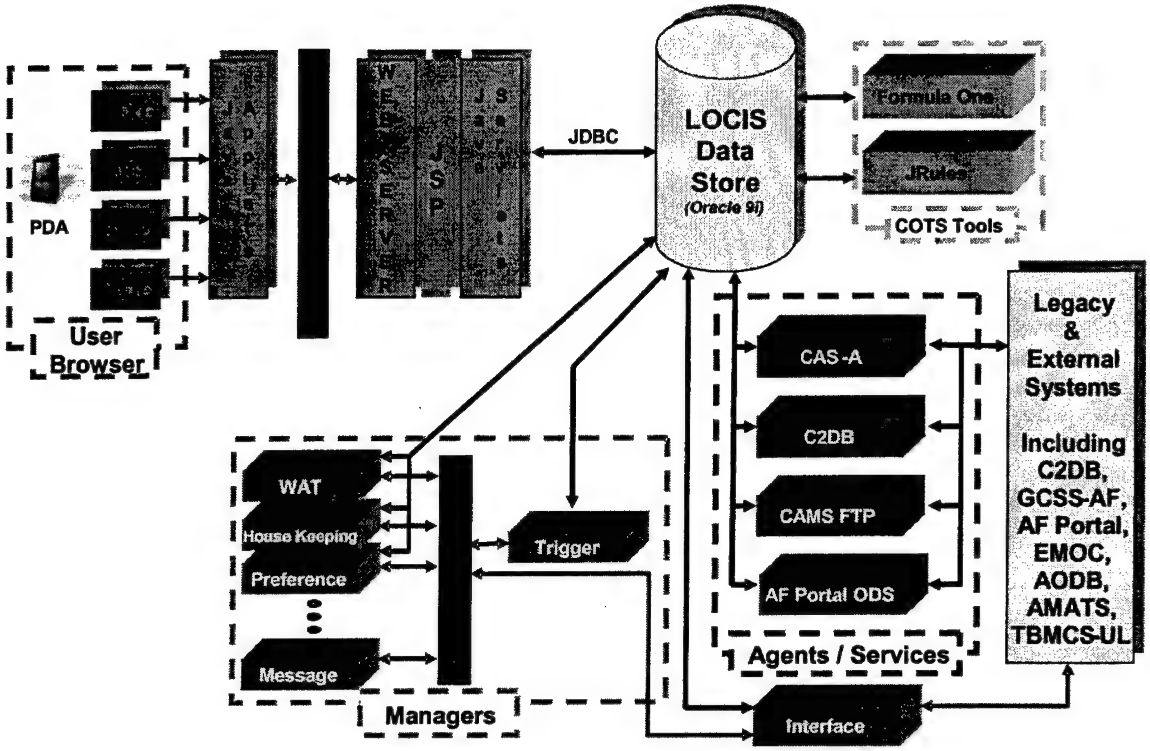


Figure 8. LOCIS Architecture

To enable the goals of Spiral 3, particularly the modularity and standardization goals, several changes were made in the three technical areas. The following is a summary of the key mission application activities in these three areas.

5.3.1 Information Fusion

The fusion of information was a key focus for Spiral 2 and again in Spiral 3. In particular, for the Hurlburt Field Block Release, LOCIS required access to real-time information via the AFSOC C2DB. However, with the requirement to be more standard in Spiral 3, interfaces to ODS, EMOC, CAMS and CAS-A were built. In addition to these data sources, the Electronic Data Warehouse (EDW) was also pursued. However, after multiple discussions with EDW personnel it was decided that currency of data in EDW was such that it was not valuable to LOCIS users.

To perform the CAS-A interface, DSI joined the BAE Systems team bringing their key munitions knowledge. Working closely with the LOCIS team, DSI developed a Web Service interface to munitions data from CAS-A which could be called from LOCIS for near-real time updates of munitions data and analysis based on that data.

To perform the CAMS interface, a GFE tool, developed by KLSS, called CAMS Connectivity Development Tool (CCDT) was integrated and used.

EMOC and ODS interfaces were developed through standard Oracle XML mapping and extraction techniques.

5.3.2 Decision Support

Decision support in Spiral 2 leveraged the success of Spiral 1 in the area of (1) notifications of alerts and warnings, (2) user-definable thresholds, and (3) "what-if" simulation. The "what-if" capability being provided by the KLSS Scaleable Integration Model for Objective Resource Capability Evaluations (SIMFORCE) tool. In Spiral 3, the alerts and warnings were further enhanced along with a plan for two new capabilities: a surge or deployment analysis tool and munitions. The advisory tool was to leverage the SIMFORCE "what-if" tool and the JRules rule-based advisory tool. However, scheduled priorities were such that the advisory tool was developed in concept only. The following paragraphs summarize the Spiral 3 decision support capabilities:

a. Alerts and Warnings – Spiral 3 changed the paradigm of the alerts and warnings. No longer did the user need to go to a particular screen to set and monitor alerts. Each screen was enabled with an alert button much like each screen was given a print capability. The alert button opened a window of options to add/remove and update the data element or situation to be monitored by the alert. This included A/C availability alerts brought forward from Spirals 1 and 2, deployment, munitions, and launch sequence alerts, and new munitions availability alerts.

b. Surge and Deployment Planning tool – The biggest challenge to Spiral 3 was the tool to assess the surge and deployment planning. Within this tool were embedded capabilities that included Health of Fleet, Munitions analysis, system integrity and algorithms that leveraged user-defined evaluation factors. In the end, the final product was an extremely useful planning tool that allowed the user to be alerted when an element of the plan was exhibiting behavior that could jeopardize it. The result is both a planning tool and a predictive monitoring tool that performs background checks in providing a proactive capability.

c. Asset Forecast – The asset chosen in Spiral 3 for this capability was munitions. Algorithms behind the view calculate asset availability from the current date forward up to thirty days. The results are shown visually in daily green/yellow/red squares indicating predictions of whether the available munitions could meet the planned requirements for a particular day. Green indicates fully met, yellow partially met, and red not met at all. This view could be used to track any asset forecast. Also note that this screen has an "alert me" button that allows a user to be notified if availability is going to be difficult in X number of days, as defined by the user. See Figure 9 for the Munitions Forecast View.

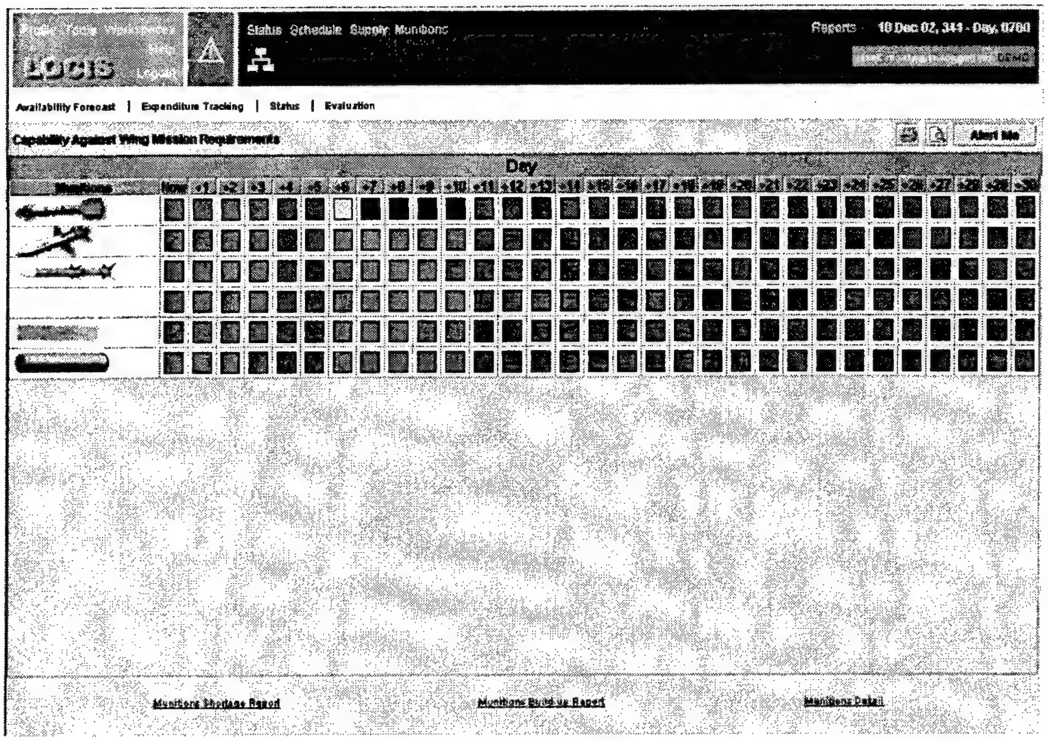
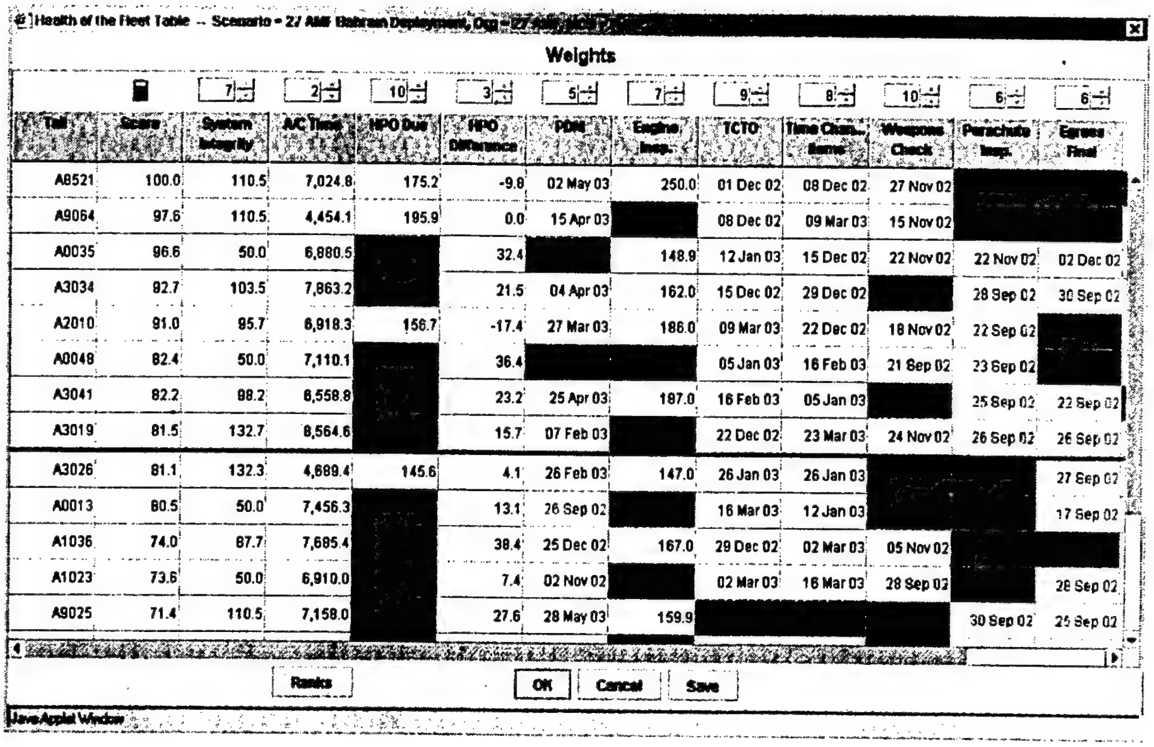


Figure 9. Munitions Forecast View

One view within the deployment planning capability is shown in Figure 10. This is the Health of Fleet view that defines the critical evaluation parameters, their user-defined level of importance (weight) and the tail number ranking. Very quickly it is possible for the user to note the critical activities that will come due before or during the proposed deployment, surge or other scheduling event. It is possible on this screen to change the weight of each activity and then re-calculate the tail ranking. Other views within the deployment planning capability are the system integrity table and the munitions evaluation table, which allows the user to map munitions for the upcoming activity. Like all LOCIS activity, this capability was designed by working closely with the user and providing solutions to their needs.



Tail	Score	System Integrity	A/C Time	HPO Due	HPO Difference	PDM	Engine Insp.	TCTO	Time Chan... Items	Weapons Check	Parachute Insp.	Egress Final
		7	2	10	3	5	7	9	8	10	6	6
A8521	100.0	110.5	7,024.8	175.2	-9.8	02 May 03	250.0	01 Dec 02	08 Dec 02	27 Nov 02		
A9064	97.6	110.5	4,454.1	195.9	0.0	15 Apr 03		08 Dec 02	09 Mar 03	15 Nov 02		
A0035	96.6	50.0	6,880.5		32.4		148.9	12 Jan 03	15 Dec 02	22 Nov 02	22 Nov 02	02 Dec 02
A3034	92.7	103.5	7,863.2		21.5	04 Apr 03	162.0	15 Dec 02	29 Dec 02		28 Sep 02	30 Sep 02
A2010	91.0	95.7	6,918.3	156.7	-17.4	27 Mar 03	186.0	09 Mar 03	22 Dec 02	18 Nov 02	22 Sep 02	
A0048	82.4	50.0	7,110.1		36.4			05 Jan 03	16 Feb 03	21 Sep 02	23 Sep 02	
A3041	82.2	88.2	6,558.8		23.2	25 Apr 03	187.0	16 Feb 03	05 Jan 03		25 Sep 02	22 Sep 02
A3019	81.5	132.7	8,564.6		15.7	07 Feb 03		22 Dec 02	23 Mar 03	24 Nov 02	26 Sep 02	26 Sep 02
A3026	81.1	132.3	4,689.4	145.6	4.1	26 Feb 03	147.0	26 Jan 03	26 Jan 03			27 Sep 02
A0013	80.5	50.0	7,456.3		13.1	26 Sep 02		16 Mar 03	12 Jan 03			17 Sep 02
A1036	74.0	87.7	7,685.4		38.4	25 Dec 02	167.0	29 Dec 02	02 Mar 03	05 Nov 02		
A1023	73.6	50.0	6,910.0		7.4	02 Nov 02		02 Mar 03	16 Mar 03	28 Sep 03		28 Sep 02
A9025	71.4	110.5	7,158.0		27.6	28 May 03	159.9				30 Sep 02	25 Sep 02

Figure 10. Deployment Planning Health of Fleet View

5.3.3 Dynamic User Interface

The dynamic user interface development in Spiral 3 leveraged the work from Spiral 1 and 2. A number of operational capabilities were updated based upon user comments and several new capabilities were added. Throughout the LOCIS spirals, human factors played a critical role in the development of views and collecting user feedback. This was particularly true for the development of the status at-a-glance view, which contained the combined view of status and schedule as well as supply information. The original design in Spiral 1 was well received and updated in Spiral 2. However, one key problem was the ability to view the full wing on one screen. This was a key comment received from multiple users. To address this issue, the LOCIS team added this requirement to the other user interface requirements and made minor modifications to the screens. One modification was a compression button that allowed the user to compress all icons to one screen. This changed the format of the screen but allowed the user to choose his or her personal viewing preference.

A new capability developed in Spiral 3 is shown in Figure 11. This is the geographic view that maps parking locations via GPS coordinates to an aerial map of the base (the base pictured is Langley AFB). To allow the user to zoom in and out required icons to be dynamically resizable. This required a complete redesign of the icon. However, human factors ensured that the icon behavior is the same on all pages, meaning that the mouse-over and drill downs are identical. This is just one case where human factors played a key role in the development and evolution of LOCIS views.

Figure 11. LOCIS Geographic View

Another area that has evolved over the three spirals was the concept of a workspace. By Spiral 3 this concept had become similar to a "Favorites" folder when surfing the Internet, but also having the ability to combine views into a favorite selection. For example, single, dual and quad panels are available to be created by user choice and saved under an individual user's workspace. These views are filled with any of the over thirty views available within LOCIS. The views in a workspace are active, live panels for which the look, feel, and behavior are identical to the individual web pages from which they are chosen. Figure 12 shows such a web page. It is a dual panel showing supply aircraft and related supply drivers on the left panel and the status of all the aircraft on the right panel. This is similar to the view that is used most often by users at Hurlburt Field.

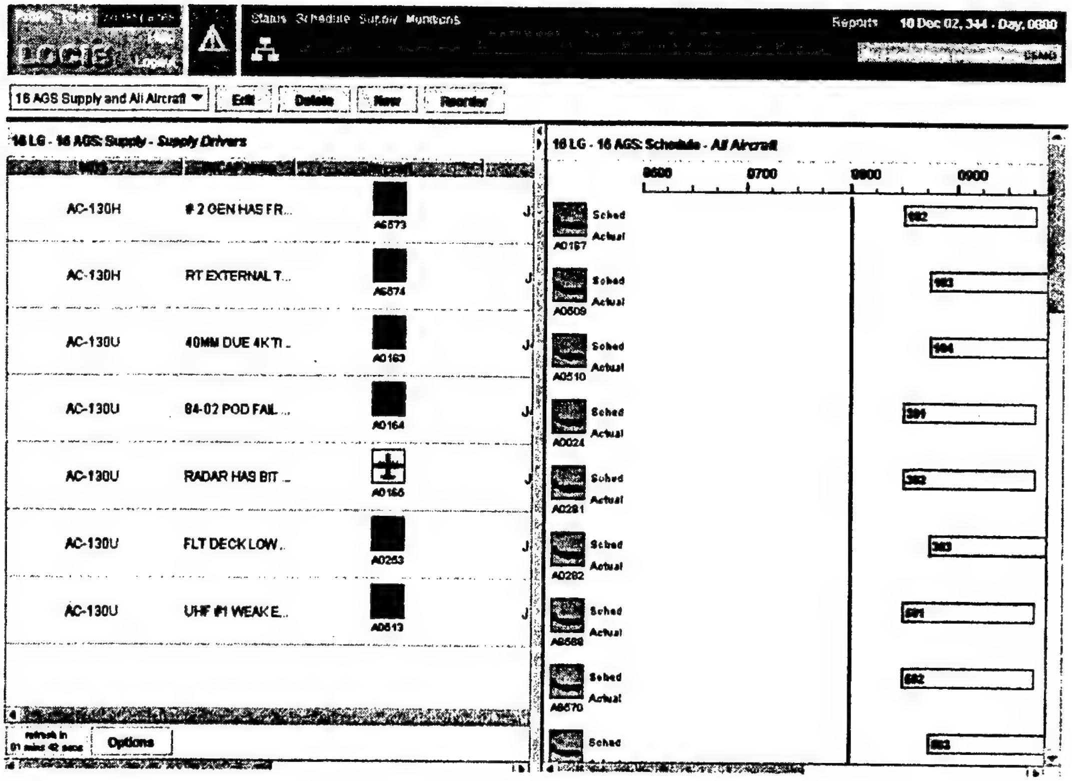


Figure 12. Dual Panel Workspace

5.4 Collaboration

As in previous spirals, LOCIS collaborated with a number of organizations in Spiral 3.

a. Air Force Command and Control Intelligence Surveillance Reconnaissance Center – AFC2ISRC has been the key sponsor of LOCIS throughout the contract. Their support and attendance at PDRs, CDRs, and demonstrations has been important to the success LOCIS achieved.

b. Air Force Special Operations Command at Hurlburt Field – The support and development of the LOCIS Living Lab at Hurlburt Field has been a key relationship that has allowed AFRL to test LOCIS in a living lab environment and to capture vital user feedback.

c. Air Combat Command (ACC) – The ACC at Langley had offered themselves as the Field Test for LOCIS and has been instrumental in providing feedback during the LOCIS development.

d. Air Force Portal – Air Force Portal has supported LOCIS and even offered to place the LOCIS demonstration on their portal. The Spiral 2 software was delivered to AF Portal in the spring of 2002. In addition, a data mapping between ODS and LOCIS was delivered at the end of Spiral 3.

5.5 Demonstrations

To validate the LOCIS efforts, it is important to demonstrate the concepts each year to the users. The demonstrations for Spirals 1 and 2 were identified in the background section of this document. The final demonstration for Spiral 3 was held at the LOGTIE facility at Wright Patterson AFB. The demonstration was held in conjunction with the LUG meeting and was attended by the following personnel:

Name	Organization
Maj Mark Gray	AFC2ISRC/LG
1st Lt Michael Carawan	388MOS/MXOO
CMSgt Robert Boyd	HQ ACC/LGXI
CMSgt Darrell Bridges	HQPACAF/LGMM
CMSgt Joe Moran	33AMXS/MAZ
SMSgt Stephen McLaughlin	33AMXS/MXAAO
SMSgt Andrew Smith	1AMXS/MAXP
MSgt Leonard Stolirchick	1EMS
TSgt Bruce Moore	16MXG/CDP
TSgt Brian Sternberg	AFSOC/LGMX

In addition to the LUG demonstration, a demonstration was given to a number of key LOCIS collaborators. The attendance list for this meeting is as follows:

Ronald Wright	MSG/ESS
Edwin Allen	AFRL/VACD
Henry Gifford	MSG/ESS
Todd Trickler	MSG/ESS (BTAS)
Rick Cowan	MSG/ESS
Randy Koram	AFMC/XP-AO
Louis Scacca	AFRL/HES
Gary Hardenburg	BAE SYSTEMS
Clark Moskop	BAE SYSTEMS
Rob Roy	DSI
Deb Mitta	GTRI
Shana Shelton	MSG/ESD (EDW)
Dave Erickson	GTRI
Gary Smith	AFRL/PRTA
Cheryl Holtz	AFRL/PRTA (UTC)
JB Schroeder	AFRL/VACC
Barbara Masquelier	AFRL/HESR (Chief)
Christopher Curtis	AFRL/HESR (LOCIS PM)

A third and final demonstration was given to the SLAP members. Those attending this meeting were as follows:

Name	Organization
Col Peaches Kavanaugh	AFC2ISRC/LG
Col Steve Cooper	AETC, 12^{th} LG/CC
Col Charles Williams	AFSOC/LG
Col Ronnie Mercer	AFLMA/CC
Col Karl Lewandowski	AMC/LGM
Col Richard Berry	16^{th} MXG/CC
Lt Col Kenneth Grimes	ACC/LGXI
Maj Mack Breeland	USAF/ILMM
Ms. Tricia Gober	SSG/ILM
Mr. Dan Kugel	AFRL/XPH
Col (Ret) Steve Powers	KLSS
Col (Ret) Bob Johnson	CACI
Col (Ret) Robert Mc Gill	CACI
CMS (Ret) Clark Moskop	BAE SYSTEMS
CMS (Ret) Dick Weimer	KLSS
Mr. Gary Hardenburg	BAE SYSTEMS
Mr. Chris Curtis	AFRL
Ms. Barbara Masquelier	AFRL

To support these demonstrations, a Demonstration Plan (CDRL A010) was developed and delivered. In addition, to assist in preparing and performing the demonstration, a Training/Administrator's Plan (CDRL A012) was developed and delivered. Reference either of these documents for more specific information on the demonstration hardware, software and scenario—see Appendix D.

5.6 Qualitative and Quantitative Reports

It is very important to the LOCIS sponsor that the research performed and the products/capabilities created are what the end user wants. To meet this goal, several reports were generated each year and used to measure the success of LOCIS. More specifically, a transition plan, Cost Benefit Analysis (CBA) and final report of user feedback and comments were created. The transition plan for Spiral 2 was delivered in the Technology Transition Report (CDRL A016). The CBA and feedback/comments can be found in Appendix A and in Appendix B, respectively. In addition, this final report captures a summary of the Spiral 3 effort.

5.7 Program Management

BAE SYSTEMS managed the LOCIS program from a series of documents including the Program Plan of Execution (PPofE), which was tailored specifically for the LOCIS development effort. The PPofE is available from the Data Accession List (CDRL A008). The Data Accession List also includes the following documents: Operational Architecture Specification, Software Development Plan, Style Guide for the C Language, and Style Guide for the Java Language.

The LOCIS success was assisted by the use of a website with an area accessible to everyone and a password protected area for developers, customers and users. The website address is www.program-support.com/LOCIS/index.

6 Summary

The LOCIS program in Spiral 3 has continued to expand capabilities—but more importantly, the program has remolded the architecture to promote an economical base-to-base deployment. This has been accomplished by creating a complete thin client application and a modular architecture. In addition, the data source interfaces have been rewritten to standard USAF sources including CAS-A, CAMS, EMOC and ODS. The results have been extremely well received from the users at Hurlburt Field and from numerous decision makers across the USAF. Spiral 3 has increased the cost benefits for LOCIS as can be seen in the Cost Benefit Analysis in Appendix A.

The CBA and also user comments have met many of the exit criteria. A field test that is being planned will be the final test of the exit criteria. However the following items can be noted:

a. The alert/warning working autonomously provides a proactive decision support capability.

b. Though only used in day-to-day scenarios, the fused information on the multiple screens should reduce time to replan during a crisis-action contingency.

c. The CBA proves reduced staff hours.

d. The CBA and also user comments affirm the reduction of time to assess the input of operational changes.

e. Though only used in day-to-day scenarios, initial assessments predict improved assessment to support tasked combat missions.

The Hurlburt Field Living Lab and the multiple spiral demonstrations have proven that LOCIS stayed focused on the needs of the warfighter throughout the program's development.

Appendix A – Spiral 3 Cost Benefit Analysis

Introduction

This appendix describes the methodology and presents the framework used to develop this CBA. The purpose of the CBA is to document tangible and intangible cost benefits of LOCIS for Air Force operational and logistics command and control decision-makers. Examples of intangible costs are: standard Web GUI across the Air Force, accurate data from legacy systems, intuitiveness of standard interface and the cost of blue suit manpower (technicians) returning to their primary jobs back on the flight line.

The methodology is based on DoD and commercial practices, and has been tailored to fit the Air Force. One example of this is the usage of the term "Cost Avoidance." Cost Avoidance refers to the release of technicians back to their primary duties. There are no realized dollar savings, rather better use of manpower resources. Due to the increased reduction in manpower in the Air Force, references to cost savings are carefully evaluated because these costs will be removed from an organization's operating budget. This action reduces manpower that was never funded to perform the additional duties outside their Air Force Specialty Code (AFSC) duties. It has been made very clear to the team during all data collections that there are not enough personnel to maintain current aircraft. For these reasons, "Cost Avoidance" terminology is used. LOCIS has, and will continue to demonstrate that core capabilities allow wing and squadron decision-makers to do their job faster and more efficiently. This will allow them to perform other critical tasks not being performed today due to a lack of time. In addition, when slots can be reduced, in particular for data gathering and reporting, it is envisioned that these personnel would return to performing their primary AFSC of maintaining aircraft and related support equipment.

The basic premise of the methodology is to evaluate cost benefit from multiple viewpoints. The most common viewpoints are the cost benefit related to an organization's labor and product. The product viewpoint has not been evaluated. The primary product produced and enabled by LOCIS are decisions, which are very subjective, especially when they are converted to cost benefit. However, to remain compliant with the original premise of multiple viewpoints, cost benefits were created by role, OG, LG, Deputy Operations Group Command Maintenance (DOG/MA), Deputy Logistics Group Commander, Chief Operations Group, Chief Logistics Group, Sortie Generation OIC, Sortie Generation Chief, MOC Controller, MOC Senior Controller and Production Super and tied to a capability, reporting take offs, identifying trends, reporting completed tasks or updating the status board and by LOCIS requirements accomplished in Spiral 3. Each of these is discussed in more detail in the following paragraphs.

The framework used to calculate the cost benefits is through spreadsheets. This provides key management personnel on the program the ability to incorporate updates and changes as required.

The following definitions are provided to clarify the techniques utilized to develop the CBA.

a. Functional Process Improvement – The application of a structured methodology to define a function's "as is" environment, its objectives and strategy for achieving those objectives, and a program of incremental improvements made through functional, technical, and economic analysis and decision making. DoD 8020.1-M, Interim Management Guidance on functional Process Improvement documents this program.

b. Activity Based Costing – A technique that identifies the costs of producing the primary products and services for a business area.

c. Economic Analysis – A technique that provides for the systematic comparison of alternate approaches to problem-solving, using financial analysis and risk analysis algorithms. Individual costs and benefits are associated with alternative investment opportunities, taking into account the lifecycle characteristics of each investment.

d. Cost Avoidance – Cost Avoidance refers to the release of technicians back to their primary duties. There are no realized dollar savings, rather better use of manpower resources. This is a component of the Economic Analysis.

e. Return On Investment – The amount of time required to pay for the savings documented in a business case or Functional Economic Analysis (FEA). This is a component of the Economic Analysis.

f. Functional Economic Analysis or Cost Benefit Analysis – A well-documented decision package that supports a proposed expenditure of investment funds along with a plan of actions. It is the final result of using all of the tools, techniques, methodologies, tactics and strategies of the FPI Program.

The numbers and results presented herein are estimates developed by functional personnel based on information collected from user interviews. Again these numbers only apply to the roles, capabilities and requirements demonstrated in Spiral 3 and the block release. The roles used in the CBA include the OG, LG, DOG/MA, Deputy Logistics Group Commander, Chief Operations Group, Chief Logistics Group, MOC Controller, MOC Senior Controller, and Production Super. In addition, the numbers represent the cost benefit for a wing consisting of three squadrons.

Summary and Conclusions

Table A.1 represents the reduction in labor hours, cost avoidance and return on investing from the viewpoints of role and capabilities, and requirement as they related to the LOCIS Spiral 3 demonstration.

Table A.1 – Spiral 3 CBA Summary

LOCIS CBA: Spiral 3 Summary		
Percentage Reduction in Labor Hours Per Wing (3 Squadrons)		
By Role		51%
By Requirement		51%
Cost Avoidance Per Year Per Wing (3 Squadrons)		
By Role	$	1,701,928
By Requirement	$	771,942
Cost Avoidance Per Month Per Wing (3 Squadron)		
By Role	$	141,827
By Requirement	$	64,329
LOCIS Cost (Year 1 Only)	$	454,017
Return on Investment (in Months) (Recuring costs not included.)		
By Role		3
By Requirement		7

The results are presented as ranges and should be viewed as estimates. Keep in mind that a benefit is something of value produced by an alternative solution. It is the Return On Investment (ROI). All potential benefits must be quantified or they cannot be used in the analysis. For example, the reduction in labor hours are depicted as 51%, however a more accurate view would be to expect roughly a 50% reduction in the labor hours required for activities enabled by LOCIS. This is also true for the ROI. The ROI is depicted to occur in 3-7 months; however, a more accurate portrayal of this is that it occurs in less than 12 months. DOD 8020.1-M states that an investment is warranted if the ROI occurs within three years. It is important to note that the ROI is expected to shorten as additional capabilities are demonstrated in the upcoming spirals.

Standard formulas were used in the calculations to determine each benefit listed below:

Reduction in Labor Hours = 1 – (Future Labor Hours with LOCIS / Current Labor Hours without LOCIS)

Cost Avoidance = Current Labor Cost without LOCIS – Future Labor Cost with LOCIS

Return On Investment = Installation/Implementation Costs / Cost Avoidance Per Month

Cost Assumptions

The primary components that drive costs are labor and implementation, support and sustainment. Table A.2 presents manpower costs for the roles supported in Spiral 1. Costs are presented in yearly, monthly, weekly, daily and hourly amounts. The numbers above the Manpower Cost headings were used to calculate the corresponding amount for each role. In addition, the number of workdays per year and per month are presented and used to calculate activity per month and activity per year for each viewpoint.

Table A.2 – Manpower Assumptions

LOCIS CBA: Assumptions					
		12	52	219	1752
Manpower Cost	Salary	Monthly	Weekly	Daily	Hourly
O6 - Colonel: LG	$ 112,458	$ 9,372	$ 2,163	$ 514	$ 64
O5 - Lt. Col.: DLG	$ 86,989	$ 7,249	$ 1,673	$ 397	$ 50
O3 - Capt: SGF OIC	$ 64,416	$ 5,368	$ 1,239	$ 294	$ 37
E9 - Chief: Chief LG, MOC Sen Ctrlr, Chief MSgt, Pro Supr, SGF Chief	$ 63,116	$ 5,260	$ 1,214	$ 288	$ 36
E6 - Tech Sgt: MOC Controller	$ 40,630	$ 3,386	$ 781	$ 186	$ 23
Number of Work Days Per Month	18.25				
Number of Work Hours Per Year	1752				

Table A.3 presents the costs associated with the installation, implementation, support and sustainment of LOCIS. Included in these costs are the costs of hardware, software and labor. Labor costs have been calculated based on the number of man-months times the cost per man-month. Travel has been included for installation and training.

Table A.3 – LOCIS Spiral 3 Installation, Implementation, Sustainment, Support Costs

Installation/Implementation Costs Per Wing (3 Squadron Wing with similar MDSs)				
Item	**Cost**	**Man-Months**	**Cost Per Man-Month**	**Sustainment (Recurring)**
Material				
LOCIS				
Hardware Server (Dell PowerEdge 4400)	$ 10,018	NA	NA	
Software				
Oracle DB Server	$ 4,599	NA	NA	
Weblogic	$ 17,000			
Formula One	$ 19,950			
FM - NET (ASRT)				
Hardware	$ 6,900	NA	NA	
Software	$ 3,300	NA	NA	
Labor				
LOCIS				
Installation & Testing	$ 180,000	3	$20,000	
Training	$ 30,000	0.5	$20,000	
Support	$ 60,000	3	$20,000	20k Per Yr
FM Net				
Vocabulary	$ 30,000	2	$5,000	
Installation	$ 10,000	1	$10,000	
Training	$ 5,000	0.5	$10,000	
Support	$ 24,750	1.5	$5,500	8K Per Yr
SIMFORCE				
Data Setup (Failure & Resource Analysis)	$ 30,000	5	$6,000	
Training	$ 15,000	0.5	$10,000	
Support	$ 7,500	1	$2,500	2.5K Per Yr
Total	$ 454,017			

Viewpoint 1 – By Role and Capability

Table A.4 presents major capabilities grouped by role. The foundation of this CBA lies in the difference between similar work accomplished without LOCIS (or currently) and with LOCIS. LOCIS functional expert's (LUG and SLAP members) comments, plus the observations from the many field visits conducted, identified the amount of time spent performing each capability each day and the number of people within each role performing the task. These components drive the costs that calculate effort expended for a major capability. They are multiplied together, along with the labor costs for the applicable role to achieve a cost by activity. Labor hours and costs, per month and per year, are calculated using the days per month and per year identified in Table A.2 – Manpower Assumptions.

Table A.4 – Spiral 3 Labor and Costs By Role and Capability

LOCIS CBA: By Role						
	Current (w/o LOCIS)			Future (with LOCIS)		
Wing Activity By Roles	Time (Hours per Day per Person)	Number of People Per Day	Cost	Time (Hours per Day per Person)	Number of People Per Day	Cost
LG, O6, Colonel						
Monitor Aircraft Status	2	1	$128	1	1	$64
Monitor Flying Schedule	1	1	$64	0.5	1	$32
Problem Notifications	1	1	$64	0.5	1	$32
Solution Alternatives	2	1	$128	1	1	$64
Deputy LG, O5, Lt. Col.						
Monitor Aircraft Status	2	1	$99	1	1	$50
Monitor Flying Schedule	1	1	$50	0.5	1	$25
Problem Notifications	1	1	$50	0.5	1	$25
Trend Analysis	1.5	1	$74	0.5	1	$25
Solution Alternatives	2	1	$99	1	1	$50
Chief LG, E9, CMSgt						
Monitor Aircraft Status	2	1	$72	1	1	$36
Monitor Flying Schedule	2	1	$72	1	1	$36
Monitor Munitions Status	0.5	1	$18	0.2	1	$7
Problem Notifications	2	1	$72	1	1	$36
Solution Alternative	2	1	$72	1	1	$36
Sortie Gen OIC, 03, Capt, Sortie Gen Flt Chief, E8, SMSgt						
Monitor Aircraft Status	2	6	$441	1	6	$221
Select A/C for Deployment	2	6	$441	0.5	6	$110
Monitor Flying Schedule	2	6	$441	1	6	$221
Problem Notifications	1	6	$221	0.5	6	$110
Trend Analysis	1	6	$221	0.5	6	$110
Solution Alternative	1	6	$221	0.5	6	$110
MOC Controller, E6, Tech Sgt; Sen Controller, Prod Super, E7, MSgt;Munitions NCO, E7, MSgt						
Slide Generation (Standup)	1	21	$487	0.5	21	$243
Aircraft Status Recording (FM Net)	4	21	$1,948	1	21	$487
Monitor Aircraft Status	6	21	$2,922	4	21	$1,948
Select A/C for Deployment	1	21	$487	0.5	21	$243
Monitor Flying Schedule	6	21	$2,922	4	21	$1,948
Monitor Munitions Status	3	6	$417	1	6	$139
Problem Notifications	4	21	$1,948	2	21	$974
Solution Alternative	4	21	$1,948	2	21	$974
Total	60		$16,129	29.7		$8,357
Activity Per Month	1,095		$294,346	542		$152,519
Activity Per Year	13,140		$3,532,152	6,504		$1,830,224

Viewpoint 2 – By Requirement

Table A.5 presents labor hours and costs by requirements. LOCIS functional experts identified the amount of time spent performing each requirement each day and the number of people performing the task.

Intangible Benefits

In addition to benefits derived from specific measurements, LOCIS also provides a number of intangible benefits.

a. Accurate data from legacy systems.

b. Standard web GUI across Air Force.

c. Intuitive interface.

d. Manpower not accounted for within the government is considered intangible (e.g., support of systems, data collection, managing MOC boards).

e. Improved data accuracy of C2 systems.

f. Increases/improves decision time of wing leadership.

g. Real time data display.

h. Saves on lost sorties.

i. Saves management from needing to reconfigure an aircraft multiple times.

j. Reduction in the number of late takeoffs.

Table A.5 – Spiral 3 Labor and Costs By Requirement

LOCIS CBA: By Requirement																
		Current (w/o LOCIS)			Future (With LOCIS)											
Rqt Nbr	Title	Time Per Day (Hrs)	Nbr of People Per Day	Cost	Time Per Day (Hrs)	Nbr of People Per Day	Cost	Notes	LG	DLG	Chief LG	MOC	Moc Sen	SGF OIC	SGF Chief	Pro Sup
1	Identify User	0.1	8	$32	0.1	8	$32	Sys Admin	1	1	1	1	1	1	1	1
2	Identify Job Responsibility				0.1	8	$32	Sys Admin	1	1	1	1	1	1	1	1
3	Identify Position and User Access Restrictions				0.1	8	$32	Sys Admin	1	1	1	1	1	1	1	1
4	Identify Subject / Topic				0.1	8	$32	Wrk Spc Mod	1	1	1	1	1	1	1	1
5	Identify Default Data Elements				0.1	8	$32	Wrk Spc Mod	1	1	1	1	1	1	1	1
6	Identify Default Data Changed by User				0.1	8	$32	Wrk Spc Mod	1	1	1	1	1	1	1	1
7	Identify Placement of Data				0.1	8	$32	Wrk Spc Mod	1	1	1	1	1	1	1	1
8	Define Critical Resources	0.5	8	$159	0.1	8	$32		1	1	1	1	1	1	1	1
9	Define User Thresholds				0.1	8	$32		1	1	1	1	1	1	1	1
13	Establish Available A/C Threshold				0.1	8	$32		1	1	1	1	1	1	1	1
21	Establish Abort Rate Threshold				0.1	2	$9			1				1		
22	Establish Repeat/ Recur Rate Threshold				0.1	2	$9			1				1		
23	Define Munitions Thresholds	0.5	2	$43	0.1	2	$9			1	1					
24	Define Supply Thresholds				0.1	4	$16			1				3		
40	Receive Weekly Flying Schedule	0.5	8	$159	0.1	8	$32		1	1	1	1	1	1	1	1
43	Define Vehicle Consumption Standards Requirements	0.5	2	$30	0.3	2	$18				1	1				
44	Define POL Consumption Standards	0.5	2	$30	0.3	2	$18				1	1				
45	Define Wing Aircraft System Configuration	0.7	2	$50	0.3	2	$22								1	1
46	Define AGE Standards	0.5	2	$30	0.3	2	$18				1	1				
48	Project Future Events / Requirements	1	1	$50	0.5	1	$25			1						
49	Determine How Shortfall Can Be Rectified	2	4	$319	0.7	4	$112		1			1				2
50	Determine if the Unit Can Support A Requirement	1	2	$86	0.5	2	$43			1				1		
51	Identify Timing Associated with supporting a Threshold	1	2	$87	0.2	2	$17		1			1				
53	Adjust Future Mission Requirements	2	3	$247	1	3	$123		1			1				1
55	Collect Specified Threshold Actual Data							Transparent	1	1	1	1	1			
56	Compare Actuals to Thresholds							Transparent	1	1	1	1	1			
58	Identify Negative Trends (Timing)	1	8	$318	0.5	8	$159		1	1	1	1	1	1	1	1
59	Identify NMCS Status	0.5	5	$84	0.25	5	$42					1	1	1	1	1
60	Identify PMCS, PMCM, PMCB A/C	0.5	5	$84	0.25	5	$42					1	1	1	1	1
61	Identify Available A/C Location	0.5	9	$150	0.25	9	$75					2	1	1	1	4
62	Identify A/C Configuration	2	4	$237	1	4	$118					2				2
63	Identify Available Types	1	2	$59	0.5	2	$30					1			1	
64	Identify Available Munitions Locations (On-Site and Off-Site Storage, etc.)	2	3	$218	0.5	3	$54			1	1	1				
65	Identify Type Available and Quantity	1	2	$59	0.5	2	$30					1			1	
66	Identify Available Components (On-hand or in Supply)	0.5	2	$30	0.3	2	$18					1			1	
67	Assign/Identify Available Tail Numbers To Mission	2	3	$247	1	3	$123		1			1				1
68	Assign/Identify Available Munitions to Mission	2	3	$247	1	3	$123		1			1				1
69	Determine Shortfalls between tasks and resourceas	1	8	$317	0.5	8	$159		1	1	1	1	1			3
70	Identify NMCS/MICAP, NMCM, NMCB A/C	0.5	5	$84	0.25	5	$42					1	1	1	1	1
71	Identify A/C Location	0.5	5	$84	0.25	5	$42					1	1	1	1	1
72	Identify Scheduled Maintenance	0.5	2	$30	0.25	2	$15					1				1
73	Identify Real-Time Sortie Generations A/C Discrepancies	1	10	$390	0.75	10	$292		1	1	1	1	1	1	1	3
74	Identify A/C Scheduled for Maintenance Problems	1	8	$317	0.5	8	$159		1	1	1	1	1			3
86	Identify TPFDD Tasking Problems	2	2	$175	1	2	$87		1			1				
93	Identify Weather Problems	1	5	$182	0.75	5	$136			1		1		1	1	1
96	Identify Problems with Shift Assignments	2	3	$218	1	3	$109							1	1	1
106	Prioritize Problem	2	5	$363	0.5	5	$91			1		1		1	1	1
108	Identify Sources of Supply	0.5	4	$66	0.25	4	$33					1	1		1	1
109	Identify Quantity On-Hand	0.5	6	$109	0.25	6	$54			1	1	1	1	1		1
110	Identify Parts Arrival Time	0.5	6	$109	0.25	6	$54			1	1	1	1	1		1
114	Identify Date Of Arrival	0.5	7	$127	0.1	7	$25			1	1	1	1	1	1	1
115	Flight Line Requisitions Part	0.5	5	$84	0.3	5	$50					1	1	1	1	1
118	MOC Pushes Highlighted A/C Button Problem Spelled Out	0.2	4	$26	0.1	4	$13					1		1	1	1
119	LOCIS Users See Options for A/C	0.6	5	$118	0.2	5	$39		1			1		1	1	1
121	LOCIS Moves Original A/C into Maintenance Area	0.5	5	$84	0.25	5	$42					1	1	1	1	1
122	LOCIS Moves New A/C into Original Flying Line	0.5	5	$84	0.25	5	$42					1	1	1	1	1
175	Report Loads Begin	0.6	7	$151	0.3	7	$76						3		1	3
176	Report Completed Munitions Load	0.6	7	$151	0.3	7	$76						3		1	3
177	Report POL Status	0.5	4	$66	0.2	4	$26					1		1	1	1
178	Report Pilot Show At A/C	0.5	7	$127	0.25	7	$63			1	1	1	1	1	1	1
179	Report Maintenance Actions Status	0.5	8	$145	0.25	8	$72			1	1	1	1	1	1	2
180	Report A/C Taxi	0.5	7	$127	0.25	7	$63			1	1	1	1	1	1	1
181	Report A/C Take-off	0.5	7	$127	0.25	7	$63			1	1	1	1	1	1	1
182	Report A/C In-Flight Status	0.2	3	$25	0.1	3	$12		1			1				1
184	Report A/C Location	0.5	5	$105	0.25	5	$52		1	1	1	1	1			
189	Report Land Times	0.2	4	$24	0.1	4	$12					2				2
190	Capture Actual Data	0.5	7	$127	0.25	7	$63			1	1	1	1	1	1	1
	Total	44.70		$7,192	21.85		$3,667									
	Activity Per Month	816		$131,257	399		$66,929									
	Activity Per Year	9,789		$ 1,575,085	4,785		$ 803,143									

Note: Number of People Per Day column includes LG, OG, Deputy LG, Deputy OG, Chief LG, Chief OG, MOC Controller, and MOC Chief.

Appendix B - LOCIS Usability Evaluation Results

This appendix documents results of the LOCIS usability evaluations conducted during Spirals 1, 2 and 3. During Spiral 2, a series of evaluation sessions were conducted to assess the specific user interface features incorporated into the LOCIS Block Release capability. Also during Spiral 2, a single evaluation session was conducted in conjunction with the Spiral 2 Demonstration. During Spiral 3, a single usability evaluation was conducted in conjunction with the Spiral 3 Demonstration.

B.1 Spiral 1 SLAP/LUG Results

LOCIS Usability Demonstrations were held on 26-27 September 2000 in the AFRL/HESR LOG-TIE Facility at Wright-Patterson Air Force Base. The purpose of these demonstrations was to solicit user inputs on the set of LOCIS capabilities demonstrated for Year 1. Two usability demonstrations were conducted—one for members of the Senior Logistics Advisory Panel (held on 27 September) and one for members of the LUG (held on 26 September). Members of the Senior Logistics Advisory Panel provided LG/OG-level perspectives. Their primary objectives were to assess demonstrated LOCIS capabilities from a senior management-level perspective, as well as recommend strategies for future transition efforts. Members of the Logistics User Group offered an LG/OG staff perspective on the usability aspects of demonstrated capabilities, but they also offered their insights on potential LG/OG use of LOCIS.

In this appendix, feedback obtained from each user group is documented. A comparison of the comments attributed to each group is offered first. In comparing the feedback across groups, we identified a number of common themes, and these themes are highlighted in paragraph B.1.1. In paragraphs B.1.2 and B.1.3, the two sets of user input data are considered individually. These paragraphs provide more detailed documentation on specific comments offered by the SLAP and LUG members in response to a set of human factors questions developed for each group's usability demonstration. In paragraph B.1.4, a brief discussion outlining lessons learned and recommendations for future demonstrations is provided.

Paragraphs B.1.2 and B.1.3 focus on SLAP and LUG feedback, respectively. Note that in these paragraphs, participant comments are characterized according to one of four LOCIS capabilities demonstrated during the Year 1 Demonstration.

a. Data Management

b. Dynamic User Interface

c. Proactive Decision Support

d. Real-Time Updating of Information

During the Year 1 usability demonstrations, each of these aspects was assessed through a series of questions. Questions in a given series were designed to focus participants' comments on a set of supporting features. In paragraphs B.1.2 and B.1.3, comments associated with a given LOCIS capability are further characterized according to the set of features supporting that capability.

B.1.1 Comparison of SLAP and LUG Data

As described in the Year 1 Demonstration Plan, objectives of the two data collection sessions were different. The motivation for collecting data from SLAP members was to capture feedback directly from those users who were specifically targeted for the Year 1 effort. One of our fundamental design goals is to push the right information, to the right people, at the right time. From a human factors perspective, achieving this goal is possible only when we "know the user." By interviewing SLAP members within the context of the LOCIS Year 1 Demonstration, we were able to collect feedback representative of our intended user group. Inputs (from a senior management-level perspective) on the potential usefulness and appropriateness of demonstrated capabilities and technologies, as well as recommendations for future transition efforts, were solicited. While the intent of the SLAP data collection session was to capture top-level assessments on the applicability of capabilities demonstrated for Year 1, SLAP members were equally willing to provide more detailed inputs addressing interface design and usability.

The data collection session conducted for LUG members was designed to solicit detailed assessments of LOCIS capabilities, where the focus was on interface design and usability. In their assessments, LUG members considered content and layout of information views; technologies; design of the LOCIS web page, including the Alerts and Warnings window and the design of multiple-view workspaces; and interaction strategies required for control of LOCIS information, including the drill-down capability, PowerPoint snapshot feature, and the book marking feature. In some cases, they also used their insights to anticipate LG/OG reaction to LOCIS features.

Table B.1 summarizes the types of data collected across the two user groups. User feedback was categorized according to one of four demonstrated capabilities: data management, dynamic user interface, proactive decision support, and real-time information updating. Once categorized according to capability, comments were further classified according to the features supporting that capability.

An *x* in the column *SLAP DATA* (*LUG DATA*) indicates that data specific to a given feature was collected from the SLAP group (LUG group). As indicated in Table B.1, the data collection team was able to capture data from both user groups for a majority of the capability/feature pairs. In spite of the differences in focus and the level of detail associated with comments from each group, we identified several common themes. These themes will be addressed in the following paragraphs.

Both groups concurred on the issue of deployability. Specifically, they emphasized that LOCIS must be a deployable capability. Security was another issue of concern to the two user groups—an issue they felt the LOCIS team should continue to address during subsequent years. SLAP users were concerned at the security risks associated with misplaced proximity cards, and they identified cell phone vulnerability to jamming as an area of concern. LUG members also identified security as an issue for proximity card use. As did SLAP participants, LUG members identified jamming as a vulnerability of cell phone and RF communications capabilities.

Data-related issues were of concern to both groups—namely, sources of data, how LOCIS will accommodate for instances in which data is inaccessible, and data timeliness. SLAP members agreed that LOCIS must have a standalone capability in those instances when the LAN is not operational and data is inaccessible. Both groups recommended incorporating a time stamp on LOCIS data screens. SLAP members recommended the inclusion of a time stamp on all PowerPoint snapshots. Ultimately, data issues will be of particular concern during the Year 2 effort, and those raised by the SLAP and LUG will be addressed.

Table B.1. Types of Feedback Collected across User Groups

DEMONSTRATED CAPABILITY	SUPPORTING FEATURE	SLAP DATA	LUG DATA
DATA MANAGEMENT	Snapshot	x	x
	Book Marking	x	x
	Pivot Table	x	x
	Drill Down Capability		x
DYNAMIC USER INTERFACE	User Preferences		x
	Integrated Flying Schedule and Aircraft Status Information	x	x
	Drill-Down Data		x
	Multiple-View Workspaces		x

DEMONSTRATED CAPABILITY	SUPPORTING FEATURE	SLAP DATA	LUG DATA
	Wing Capability Indicator	x	
PROACTIVE DECISION SUPPORT	Alerts and Warnings	x	x
	User-Definable Thresholds	x	x
	What-If Simulation	x	x
REAL-TIME INFORMATION UPDATING	Voice-Based Status Changes	x	x
	Notification of Alert and Warning Messages	x	x

Both groups expressed an interest in, as well as a need for, customizing information displays to accommodate for individual preferences.

SLAP and LUG members identified "holes" in the list of thresholds displayed in the *Threshold Settings* view, and both groups suggested a number of thresholds for potential inclusion. While both groups were receptive to the concept of user-definable thresholds, LUG members expressed more enthusiasm for the capability.

In considering the voice-based status update capability, SLAP and LUG members concurred on the need for some type of feedback mechanism in which the MOC acknowledges and verifies status changes.

Both groups identified a need for improving the manner in which users are notified of incoming LOCIS-specific e-mail messages. Their comments suggest a need for users to be cued upon arrival of such messages. They also suggest a need for these role-based e-mail messages to be readily distinguishable from alert and warning messages. One recommendation from the SLAP was to highlight LOCIS-specific e-mail messages. LUG participants suggested two separate mailboxes—one for role-specific e-mail messages and the second for alert/warning messages.

LUG member insights regarding LG/OG perceptions and reactions proved to be extremely valid. Interestingly, for each instance in which they were asked to "predict" how SLAP members might react to various LOCIS features, they correctly anticipated SLAP member reaction. The following accurate "predictions" were made.

a. LG/OG use of the "what-if" simulation capability will be driven primarily by individual preferences and management style.

b. LG/OG users will not be enthusiastic about adding a cell phone to their set of portable communications devices.

c. Radios are viewed as the most important mobile communications device. Notifications of real emergencies will likely come via radio and/or cell phone. LG/OG users will not be waiting for the LOCIS Alerts and Warnings window to notify them of real emergencies.

d. LG/OG users will be receptive to a capability allowing them to capture and save snapshots of data—as supported by LOCIS' PowerPoint capture feature.

e. Not all LG/OG users will be receptive to using LOCIS' book marking feature (providing links to real-time data) to support stand-up meetings.

f. Current LOCIS displays will provide too much detail for most LG and OG users.

g. Configuration codes should be more generic. (Some SLAP members felt configuration data would be unnecessary for the LG.)

B.1.2 Senior Logistics Advisory Panel Data

Inputs from the SLAP focused primarily on senior management-level assessments of demonstrated LOCIS capabilities (i.e., appropriateness and applicability), as well as recommendations for future transition efforts. However, SLAP participants were also willing to address interface usability and design issues, particularly as they related to features associated with OG and LG default workspaces. Participant comments were characterized according to one of the four LOCIS capabilities demonstrated during the Year 1 demonstration: data management, dynamic user interface, proactive decision support, and real-time updating of information. Each of these capabilities was assessed through an informal question-and-answer session held after the demonstration. In some instances, participants also provided written comments relevant to issues raised during the post-demonstration discussions. Verbal feedback obtained during the question-and-answer sessions, as well as written comments, is documented here.

Summary

Issues of primary importance to the group as a whole included deployability, back-up capability, sources of data, and security. The consensus was that LOCIS must be deployable (i.e., operational on laptops), and participants observed it would be a "nonstarter" if it does not work with AEF. Participants agreed that LOCIS must have a standalone capability in those instances when the LAN is not operational. A back-up capability—specifically, auto-archiving onto a designated hard drive—was also recommended. With respect to server and LAN requirements, some members expressed concern over the insufficiency of existing bandwidth at individual bases and emphasized LOCIS must become part of a base's existing infrastructure; a separate LOCIS server is not recommended. Participants perceived the proximity device as an additional and separate logon—with additional password requirements, another card to manage, and a security risk in those instances when it is lost. As such, the group was not receptive to including it as a LOCIS capability. The group did acknowledge that the concept of a common access badge is likely to be a forthcoming capability across the Air Force. Another issue of concern to SLAP participants was the data driving LOCIS, namely, sources of data and how LOCIS would accommodate for instances in which data become inaccessible.

B.1.2.1 Data Management

In considering data management aspects of LOCIS, participants provided comments on the snapshot/book marking features and the pivot table capability.

Snapshot and Book Marking Features

SLAP members were receptive to the inclusion of both snapshot and book marking features, although not all participants were in favor of using the book marking feature (providing links to real-time data) to support stand-up meetings. While they recognized the importance of maintaining ready access to real-time data (e.g., financial and wholesale/contractors databases), some participants indicated they would not be interested in using it during stand-up briefings because in most cases, they would have no opportunity to review and analyze real-time data immediately prior to a meeting. They suggested they would rather discuss data with which they were familiar and had previously reviewed—and as such, would prefer to use the PowerPoint snapshot feature in preparing for stand-up meetings. Including a time stamp on PowerPoint snapshots was suggested. In discussing the benefits of the PowerPoint snapshot feature in supporting stand-up meetings, participants acknowledged its ability to offer a manpower savings with respect to preparation time.

Pivot Table

In responding to questions addressing (1) the extent to which an LG/OG might use a pivot table to manipulate data and (2) the types of tasks that might be supported by such a tool, feedback was mixed. The differences across the group as a whole suggested use of the pivot table would depend upon personal preferences and management styles of individual users. Some members expressed an interest in applying it to their work, while others did not. Ultimately, participants

recommended it remain available as a user option. Its potential usefulness to DOG/MA users, in particular, for supporting trend analyses, was also suggested.

From reliability, validity, and accuracy perspectives, the source(s) of pivot table data was an issue of concern. Information from other bases, for example, may be suspect. Assessing the pros/cons of CAMS versus REMIS data will likely be an issue.

B.1.2.2 Dynamic User Interface

In considering aspects of the LOCIS dynamic user interface, participants commented on the critical information elements assigned to OG and LG default workspaces, as well as the appropriateness of the wing capability indicator. Some participants also expressed a receptiveness to the concept of customizing information displays to accommodate individual preferences.

Integrated Flying Schedule and Aircraft Status Information

Some participants suggested that both OG and LG default workspaces contained too much detail for the types of activities required at OG/LG levels. Such detail might be more appropriate for DOG/MA or perhaps Senior Management Office (SMO) activities. One concern was that too much detail "opens the door to micromanagement."

Members suggested additional data for OG and LG default workspaces. Additional data suggestions for the OG default workspace are as follows:

a. Aircrew availability
b. MC status
c. Refueling status/air refueling status
d. Training
e. Munitions loading
f. Range times
g. Information from other bases
h. Air field status
i. SOF status

Suggestions for the LG default workspace are as follows:

a. Equipment status
b. Spare engines
c. Munitions
d. Pallets—indicating mobilization capability
e. Multiple MDS.

Some participants felt at the LG level, the aircraft configuration information provided via drill-down from aircraft status icons was unnecessary.

Wing Capability Indicator

SLAP members were skeptical about the potential usefulness and appropriateness of a wing capability indicator. From their perspective, it satisfied no need, and they were not receptive to its inclusion on the LOCIS web page. Participants felt that a parameter such as *capability* could not be defined or measured in a meaningful manner. From their perspective, a snapshot measurement, as offered by the gauge depicted on the web page, does not adequately support the types of decisions typically reached by LG and OG users. Because of its limited power in supporting decision-making activities, participants were skeptical of its usefulness. From their perspective, a more useful indicator would be one assessing how well the wing is meeting required plans—or one reflecting contingency response time.

SLAP comments suggested that a single indicator with no drill-down capability would be unusable. However, in response to proposed drill-down data depicting status of resource availability, where resources included Maintenance, Munitions, Supply, Fuels, Transportation, and Operations, SLAP members indicated the term *availability* had limited meaning. The underlying concern is that terms such as capability and availability are subjective. At a minimum, any measurement of wing capability must be customizable, where the parameters driving wing capability are user definable. Arriving at a universal definition of wing capability would be impossible. Members also indicated that the data of potential use in measuring wing-level capability is likely to be classified. Other feedback indicated mobile readiness data is currently available through AF smart cards.

B.1.2.3 Proactive Decision Support

In considering aspects of proactive decision support provided through LOCIS, participants commented on alerts and warnings messages, user-definable thresholds, and the "what-if" simulation capability.

Alerts and Warnings

In discussing how alert or warning messages should be managed once the emergency conditions triggering them are resolved, participants' perspectives varied. In some instances, participants expressed a preference for a "hands-on" management style in which all messages would be displayed until manually saved or deleted. On the other hand, preferences for less hands-on control were also expressed, where messages would be automatically deleted once they had been reviewed.

In considering options for maintaining a log of all messages, one suggestion was for LOCIS to provide an auto-archiving capability, where alerts and warnings might be logged according to date and MDS.

User-Definable Thresholds

SLAP members want the option of selecting the thresholds of specific importance to them, although they recognized that adherence to command settings might be an appropriate use of the capability. Participants also identified "holes" in the list of thresholds displayed in the *Threshold Settings* view. Thresholds for monitoring conditions specific to the following resources were suggested:

a. Critical Auxiliary Ground Equipment (AGE)

b. Personnel/manpower

c. Supply

d. MHE (cargo loading)

While recognizing the importance of personnel and supply thresholds, participants acknowledged the difficulty in defining them. (From what source(s) is manpower availability coming? For supply data, how are unit priorities (Unit X versus Unit Y with respect to AEG/Contingency Operations) considered?) SLAP members also raised questions about the appropriateness of thresholds currently listed. LG/OG users, for example, would not wait for LOCIS to provide IFE alerts.

In response to questions about the usefulness of the capability, one suggestion was to set up a test bed among potential users, providing them with a set of adjustable thresholds to use and evaluate in a realistic environment.

What-If Simulation

Comments on the applicability of "what-if" simulation analyses were mixed, reflecting differences in user preferences and management styles. Most participants viewed it as a useful capability, but the differences in comments suggested its use would be dependent upon individual user style. In considering sources of the data used as inputs to simulation analyses, one suggestion was to incorporate a capability to share data with other bases. The impact of this particular simulation capability on the use of the Dyna-METRIC Microcomputer Analysis System (DMAS) or on other forecasting tools (i.e., how it might interface with or replace existing tools) was of interest.

B.1.2.4 Real-Time Information Updating

SLAP members felt that notifications of real emergencies would likely come via radio and/or phones and that the Alerts and Warnings window would not be the primary means through which users are notified of real emergencies. LOCIS users would be notified at the same time the MOC is notified.

Voice-Based Status Changes

SLAP members recognized a need for some type of feedback mechanism in which the MOC would acknowledge and verify status changes. One recommendation was to enable this

capability to work with the back shops to include job status/job completion, backorder parts, links to SBSS, and links to flying/maintenance schedules.

Notification of Alert and Warning Messages

Cell phone vulnerabilities to jamming and adverse weather conditions, thunderstorms in particular, were perceived as a risk among some members. In one instance, the notification of IFE and ground emergencies over a cell phone was viewed as unrealistic. Adding a cell phone to the LG/OG collection of portable devices was a concern. In reacting to the MICAP warning, some members identified a need to provide a link to real-time supply data (SBSS, regional supply information). In considering the manner in which users are notified of incoming LOCIS-specific e-mail messages, one recommendation was that such messages be highlighted to cue users of their arrival.

B.1.3 LOCIS User Group Data

As with the SLAP data, inputs from members of the LUG were characterized according to one of the four LOCIS capabilities highlighted during the Year 1 demonstration: data management, dynamic user interface, proactive decision support, and real-time updating of information. Each of these aspects was assessed through a series of questions, where the questions in a given series were designed to focus LUG participants' comments on a set of supporting features. In addition to the verbal feedback offered during this question-and-answer session, participants also, in some instances, provided written comments to the questions. During the LOCIS Year 1 Demonstration, each feature set was implemented to demonstrate how its respective capability might be supported within LOCIS. For each capability, a summary statement is provided. Following each summary statement, further details specific to the supporting features are documented. Note that verbal feedback obtained during the question-and-answer session, as well as written comments, is documented in this section.

B.1.3.1 Data Management

Summary

The data driving LOCIS was of interest to LUG members, specifically, sources of data, how LOCIS would operate when respective databases are inaccessible, and the timeliness of LOCIS data. One identified risk is LOCIS' reliance on systems external to a base's firewall, and a recommendation to notify LOCIS users when such systems are inaccessible or unavailable was offered. Incorporating a time stamp on LOCIS data screens, as well as providing built-in refreshes, were suggested as methods for enhancing user situation awareness from a perspective of data timeliness.

LOCIS compatibility with legacy systems was also a concern for users. Incompatibility with a given legacy system that currently receives extensive use may limit or preclude continued use of that system once use of LOCIS is adopted. LUG participants recommended that during the Year 2 effort, the LOCIS team identify compatibilities, as well as incompatibilities, with legacy systems.

In discussing accessibility to detailed information through a drill-down capability, LUG members validated the current underlying design strategy in which the critical data elements defining a given information display are identified and presented at the top level of the display, while secondary or supporting data are contained in a lower layer. Specifically, they stated LOCIS should provide answers to critical questions (e.g., why a line number is not ready) at the top level of a given display, not through its drill-down capability. In other words, users should not be forced to obtain critical data through a series of clicks or double clicks on numerous active regions of a display.

Snapshot and Book Marking Features

LUG participants anticipated LG/OG receptiveness to the capability allowing them to capture and save snapshots of data as supported by LOCIS' PowerPoint capture feature. Although some bases currently support stand-up meetings with real-time data (e.g., Eglin), the expectation is that not all LG/OG users will be receptive to using LOCIS' bookmarking feature (providing links to real-time data) to support of stand-up meetings.

Pivot Table

Users viewed the data manipulation capability afforded by the pivot table to be useful and suggested that repeat/recur data would be a good use of pivot table capability. Titles/labels for graphs generated "on the fly" from a pivot table must reflect the data selected in the sort operation and subsequently displayed in the graphs. During the demonstration, graphs generated from new sorting operations were not automatically relabeled. Rather, the label for the original graph (i.e., the graph displayed prior to the sorting operation) was displayed with the new graph, making it inconsistent with the data actually depicted. Users indicated that this inconsistency was unacceptable and that all titles/labels should provide a meaningful description of the data depicted. Users also identified a need to compare data across a subset of the bases listed and acknowledged the pivot table's usefulness in supporting a sort of that nature.

Drill-Down Capability

For LOCIS graphics-based data displays (e.g., aircraft status icons, bar charts depicting recap data, flying/maintenance schedule time lines depicting "scheduled" versus "actual" activities), users prefer that a drill-down capability be provided through direct interaction with the graphic itself—i.e., through selection of a "hot spot" (link) on the graphic—as demonstrated for the aircraft status icons. Users identified other LOCIS graphics-based data displays (bar charts, in particular) as appropriate for this type of drill-down activity. Specifically, each bar, corresponding to one of the categories summarized in the bar chart (e.g., *On-Time Takeoffs*, *MC Rate*, *UTE Rate* displayed in Yesterday's Wing Recap graph), would be active. Users could click on the bar corresponding to category *MC Rate*, for example, to obtain further information about the data driving the rate summarized at the top level of Yesterday's Wing Recap graph.

B.1.3.2 Dynamic User Interface

Summary

LUG participants were receptive to the concept of a customizable user interface in which a range of "set-up" options allows them to satisfy individual preferences in selecting the data elements actually displayed (e.g., bar chart categories), specifying how data should be displayed (e.g., graphically versus textually), and determining how data should be sorted (e.g., user-specified time periods for recaps and histories—daily versus weekly versus monthly). At the same time, LUG members emphasized the importance of designing an appropriate starting point (default) for content, format, and control of workspaces. "General Jumper's message," for example, might provide the default for the Recap.

Participants found the graphical depiction of flying schedule and aircraft status data (i.e., a time line distinguishing between scheduled and actual flying/maintenance activities) to be a useful display technique. They also identified the integration of flying schedule data and maintenance schedule data as useful.

LUG members emphasized the importance of designing multiple-view workspaces such that the relationships linking data between two or more views are explicit.

LUG members anticipated that current LOCIS displays would likely provide too much detail for LG and OG users. They identified the *Threshold Settings* view as one more likely to be used by lower level maintenance managers. Along these same lines, LUG members suggested that LG/OG users will most likely be interested in first reviewing a top-level graphical overview (in which "red" versus "green" aircraft are identified as such) and then drilling down from the overview information to obtain further details. Another recommendation was to include a summary capability within the flying schedule and aircraft status displays as a means of depicting an at-a-glance overview of aircraft status.

LUG members proposed several regions, objects, and data elements on the LOCIS flying schedule and aircraft status displays as potential links to drill-down data. Identified as candidate active "hot spots" were line numbers and *scheduled* and *actual* segments of the flying schedule and maintenance schedule time lines. Also identified were other types of drill-down data currently unavailable in LOCIS displays.

With respect to incorporation of the proximity device as a role-based login/logout mechanism, LUG members identified security and deployability (different requirements for RF overseas) as two issues for further consideration.

User Preferences

LUG participants identified a number of parameters that might be included among the set-up options available for user customization. One suggestion was to allow users to filter data items

for display via selection (and de-selection) from a checklist of items. They also suggested a range of areas for customizing data displays:

a. Allow data categories (e.g., recap categories) to be user selectable. Identify an appropriate set of default categories and allow users to add others.

b. Allow the data provided as part of a drill-down (e.g., tail number, location, configuration code, line number data displayed via drill-down from aircraft status icons) be user selectable.

c. Allow time periods over which data are summarized (e.g., recaps, histories) to be user selectable up to 30 days—i.e., *recap as of time period: ______, 7-Day History* versus *30-Day History*.

d. Allow the "clock" represented on the flying and maintenance schedule time lines to be user selectable (24-hour versus zulu versus local time). This option would be useful during deployments.

Integrated Flying Schedule and Aircraft Status Information

LUG members would prefer to see a single tail number entry on flying schedule and aircraft status displays, rather than a tail number entry for each successive run. Their preference is for multiple runs to be depicted on a single time line. Participants suggested that upon detection of a potential problem in meeting the next run, LOCIS might provide a cue (e.g., color code the next scheduled activity in red). Additionally, to support rapid responses during contingencies, users emphasized the need for ready identification of spare aircraft, as well as open line numbers. An OG would be most interested in knowing whether a sufficient number of aircraft are available to fill the flying schedule. Participants suggested that linking maintenance manpower data to the LG default information, including data on phase capabilities, skill levels, workload capability, work center workload (percent level at which a unit is working), would be appropriate. Information on engine status would also be helpful.

While accurate aircraft status information is necessary in supporting decision-making activities, LUG participants indicated it is not sufficient. Line status, as well as the status of blocks of lines (i.e., status according to the generation sequence) is also critical. An aircraft may have an FMC status, but it may not be "green" in its sequence (e.g., cargo is late and has not yet arrived, crew is late). Thus, LOCIS should provide status with respect to generation sequence (e.g., weapons load status, fuel status, cargo load status). This status might be referred to as *mission status readiness*. Participants suggested that such status information might be incorporated as drill-down data accessible from the line number (via a cursor roll-over or mouse click). Another option might be to display icons along the flying schedule time line, each one representing a stage in the generation sequence. Icon appearance would change to reflect status of individual stages (ready versus not ready) in the sequence. Other information available via a cursor roll-over might be WUC. Participants indicated the need to identify "on alert" aircraft, as notifications regarding the launching of such aircraft are sent.

LUG participants suggested a new "tab" for the OG Default Workspace: *Flying Schedule – PMC Only*. LUG participants also suggested that aircraft status icons remain fixed as the flying schedule and aircraft status displays are scrolled horizontally.

Drill-Down Data

LUG participants proposed a set of active "hot spots" and corresponding drill-down data. Their suggestions are summarized in Table B.2. As indicated in Table B.2, participants provided a number of observations and recommendations addressing configuration information, among them a suggestion for more generic configuration codes (e.g., air-to-air, air-to-ground) than those currently displayed upon drill-down from the aircraft status icons—with more detailed codes available via another layer of drill-down. They observed that a capability allowing users to compare an aircraft's current (actual) configuration with its required (scheduled) configuration would be useful, suggesting a drill-down capability from line and tail numbers to obtain required and current configuration, respectively. Participants observed, however, that receiving a cue when a mismatch between required and current configurations exists might be more useful.

Another type of drill-down data currently unavailable from LOCIS but suggested by LUG members was a list of parts removed from a cann aircraft.

Table B.2. LOCIS Links Proposed by LUG Members

Hot Spot	Drill-Down Data
Line number	• Sortie debrief/recap information (e.g., why A/C landed before scheduled landing time) • Line status (i.e., according to generation sequence) • Required configuration
Tail number	• Current configuration
unscheduled maintenance time periods on Aircraft Status view	• Cause of unscheduled activity • MICAP data
scheduled and *actual* time periods on Aircraft Status view	• Primary problem with NMC aircraft
scheduled time periods on Flying Schedule	• Missing items (e.g., fuels, bombs) • Required configuration
actual time periods on Flying Schedule	• Current configuration
aircraft status icons	• Items missing from required configuration
MICAP part listed in MICAP view	• Maintenance schedule

Multiple-View Workspaces

LUG participants were receptive to LOCIS' multiple-view workspaces but emphasized the importance of designing information displays such that the relationships linking data elements of two or more views are readily apparent. For LUG participants, the need for displays in which noteworthy data relationships are easily recognized was of particular interest in the tri-pane

workspaces designed for alert and warning information. LUG members suggested that LOCIS clearly identify the "drivers" of a given result or impact (e.g., MICAP report, 7-day IFE history)—i.e., link the result/impact to the data driving it. Specific LUG suggestions for enhancing the visual depiction of data links are described in the section addressing proactive decision support.

Participants also indicated an interest in reviewing different "levels" of MICAP data (e.g., wing- and squadron-level MICAPs, as well as MICAPs for a given aircraft).

B.1.3.3 Proactive Decision Support

Summary

LUG participants supported LOCIS' proactive decision support capabilities and felt those demonstrated during Year 1—namely, alerts and warnings, user-definable thresholds, and the "what-if" simulation tool—to be useful components. They also anticipated that LG/OG use of the threshold adjustment/selection capability and the simulation tool would be based on the individual preferences and management styles of an LG or OG.

Alerts and Warnings

LUG members were satisfied with the interaction approach required for responding to alerts and warnings received via the Alerts and Warnings window. Upon login, they would prefer not to receive alert or warning messages for emergencies already resolved and suggested they would not be interested in manually identifying, sorting, and deleting messages that no longer reflected actual emergency conditions. LUG members also expressed a concern that mailboxes would fill up quickly and suggested automatic deletion of those messages not read within a designated period of time. Participants did not perceive the assignment of a level of criticality or severity to a given alert or warning (e.g., high, medium, low) as a need.

User-Definable Thresholds

LUG members acknowledged the usefulness of the ability to select thresholds from a predefined list and to adjust alert and warning levels for each threshold. They suggested that analysis personnel might establish initial threshold settings. They also identified a need to create new thresholds, a capability under consideration for future demonstration. Specifically, creating a new threshold might arise from the need to monitor unique (non-routine) conditions (e.g., a one-time inspection). To support the monitoring of atypical conditions, "special purpose" or "one-time use" thresholds would be created. In creating new thresholds, participants suggested an approach allowing them to select, edit, or define "key events" (perhaps via a list of key words—e.g., WUC), where occurrences of key events would trigger alerts or warnings. For most events, linking to a WUC is possible, but isolating according to MDS would also be required. While participants rated the user-definable threshold capability as highly useful, they suggested extensive use of the capability would most likely be among lower level management roles.

When asked to critique the threshold categorization approach implied within the *Threshold Settings* view, LUG participants found it suitable. Another suggestion was to follow a

"functional" grouping, but the participants' definition of the term *functional* was not explored. One interpretation might be functional groups that include Supply, Transportation, POL, Personnel, and Facilities. They also suggested inclusion of a *Reset All* feature that would reset all thresholds to their default settings at once. Several "holes" in the list of thresholds displayed in *Threshold Settings* were identified, and LUG members acknowledged the current list of thresholds is not comprehensive (i.e., it does not reflect all conditions potentially monitored). Examples of thresholds/scenarios missing from the list are as follows:

a. Ground abort

b. Ground emergency

c. EOR situations

d. Attack warnings (generic across MAJCOMs)

e. Launch of an alert aircraft

f. Situations arising during Phase 2 scenarios (alarm red/black, FOD level), as well as those of interest from a maintenance perspective during Phase 2 scenarios (contaminated A/C, A/C recovering from an attack, A/C damaged in a dogfight)

Another suggested feature was one allowing users to view management's threshold settings.

Displaying data relationships such that they are readily identified was of particular interest in the tri-pane displays designed for alert and warning workspaces. LUG members suggested that LOCIS clearly identify the "drivers" of a given result or impact (e.g., MICAP report, 7-day IFE history)—i.e., link the result/impact to the data driving it. In the IFE Alert workspace, for example, if a subset of the items listed in the *7-Day History* view is driving a result depicted in the IFE summary bar chart, LOCIS might highlight that subset of items upon user selection of the respective bar chart category. In the MICAP Warning workspace, users suggested enhancements to the manner in which relationships between the MICAP Warning, MICAP, and Aircraft Status – NMC Only views are depicted. Specifically, users found the MICAP Warning view unnecessary. They also suggested the MICAP view include fields for source of supply and mode of transportation and that the field for NSN be removed. LUG members recommended that any link between parts listed in the MICAP view and unscheduled maintenance activities appearing in the Aircraft Status – NMC Only view be identified. One approach might be to highlight the MICAP data (MICAP view) corresponding to an unscheduled maintenance event (Aircraft Status – NMC Only view) upon user selection of the segment of the time line associated with that event.

What-If Simulation

While LUG members acknowledged the usefulness of LOCIS' "what-if" simulation capability, they viewed it to be more of a "lower level" management tool. Typically, action items are generated from lower level supervisors (namely, squadron commanders, maintenance officers, or production superintendents) and reported to higher-level management. In this manner, simulation results, from which lower level supervisors might derive a set of action items, would be reported up to the LG/OG level. Although participants anticipated LG/OG use of the simulation capability to be driven primarily by individual preferences and management style,

they did suggest its potential usefulness to OG commanders and wing schedulers in making out-year predictions (capabilities projections) across a broad range of wing scheduling activities, including next year's flying hour program (answering questions on the number of sorties a wing can produce with a given level of manpower and facilities), training requirements, and higher headquarters directives.

Participants suggested that the manner in which LOCIS currently presents simulation results would be enhanced if projections were displayed in conjunction with some baseline. In this manner, the impact of a set of anticipated conditions is more readily assessed when it is compared against results corresponding to a set of baseline conditions.

B.1.3.4 Real-Time Information Updating

Summary

LUG participants viewed data accuracy and timeliness as critical to the success of logistics, maintenance, and operations activities. They suggested potential LOCIS users would be "loyal" to their radios and would typically view them as their most important mobile communications device. Currently, radios are the primary notification device. Participants suggested potential users would not be waiting for the LOCIS Alerts and Warnings window to notify them of emergency situations. While cell phone use is not uncommon among LG and OG users, participants cautioned that many would not be enthusiastic about a requirement to carry another device. A new technology recently introduced by Motorola in which radio and cell phone capabilities are combined in a single mobile device was suggested for future consideration.

In assessing the use of cell phones, participants identified battery life as an issue to consider. Security, deployability, and vulnerability of cell phone and RF communication capabilities were identified as issues to be addressed in the coming year. Jamming was identified as a critical vulnerability of cell phones and RF capabilities.

Voice-Based Status Changes

LUG participants were receptive to the LOCIS capability allowing voice-based status updates. At the same time, they recognized a need to consider the checks and balances typically applied whenever aircraft status is changed (e.g., only the MOC has authority to change aircraft status, yet Expediters and Production Superintendents are often accountable for all data). LOCIS must accommodate the policy rules in effect at a given base. Participants recommended the incorporation of some type of feedback mechanism in which the MOC acknowledges and verifies status changes. They also recognized that this type of updating capability does not necessarily reduce a vulnerability to erroneous data. This issue of data quality will become increasingly important upon integration with CAMS.

Other status-type information that might be updated include aircraft configuration (weapons loading, fuel), last fly dates, number of days down, hangar queen status, POL, and munitions. Handling tail swaps is also an issue suggested for further consideration.

Notification of Alert and Warning Messages

When asked how LOCIS-specific (i.e., role-specific) e-mail messages should be managed, LUG participants suggested that such e-mail messages be separated from alert and warning messages. Two mailboxes—one for role-specific e-mail messages and one for alert/warning messages—were suggested. Routing role-specific e-mail messages to a user's e-mail account, instead of a LOCIS account, was also suggested. In responding to questions about the order in which messages should be listed, participants expressed a preference for a mailbox in which the most recent messages are displayed at the top of the list.

In accordance with the LOCIS approach to distinguish between "alert" and "warning" conditions, participants agreed that LOCIS should make a distinction between alerts and warnings. Users indicated a need to be cued upon arrival of incoming messages and recommended that LOCIS provide some type of cue (visual or auditory) to signal the arrival of a new message in the Alerts and Warnings window.

Participants recommended that any notification parameters for alerts and warnings—e.g., cue type (visual versus auditory versus both), hardware to which notifications are routed, notification hours—be specified for each respective threshold on an individual basis. They also identified the need for automatic routing of notifications to a default device during the periods a user is not logged into LOCIS.

B.1.4 Lessons Learned and Recommendations

Based on the data collection process followed during the LOCIS Year 1 Demonstration, we have identified several lessons learned and also offer recommendations for future demonstration efforts.

a. Reduce the number of participants in the LUG data collection sessions. Conducting LUG sessions with fewer individuals is recommended. A large group is difficult to manage (i.e., too many concurrent and side conversations amongst participants). Under these conditions, maintaining a single focus is difficult. The implication for Year 2 is to conduct more LUG data collection sessions of smaller-sized groups (preferably no more than three participants per question-and-answer session) similar to the initial LUG sessions held in April 2000.

b. SLAP members were very willing to provide feedback, including feedback specific to LOCIS interface design and usability. Detailed assessments of design and usability are not the primary data collection objectives for SLAP usability demonstrations; at the same time, providing a forum in which SLAP members are given an opportunity to critique design and usability aspects (perhaps in an informal discussion group format, rather than a structured question-and-answer session) is recommended.

c. To enhance the credibility and validity of our user data from a human factors perspective, future data collection efforts should provide a forum in which users have an opportunity to interact directly with LOCIS, even if the interaction scenario is constrained in some manner.

B.2 Spiral 2

During Spiral 2, the Human Factors team supported design of the user interface for Block Release and Spiral 2 Demonstration versions of the LOCIS capability. Led by GTRI, the Human Factors team also included individuals from the Air Force Research Laboratory (AFRL/HESR) and the University of Dayton Research Institute (UDRI). On issues specific to operational requirements, the team received support from the Operational Architecture IPT.

As a follow-up to the user interface design task—and as one means of assessing usability of the LOCIS user interface—the Human Factors team conducted a series of evaluation sessions focusing on Block Release features. Three Block Release evaluation sessions were conducted at Hurlburt Field, FL between January and March 2002. During these sessions, Hurlburt users provided feedback on features included in the LOCIS Block Release. A single evaluation session, conducted during the Spiral 2 Demonstration held at BAE Systems on 30 April 2002, addressed additional features highlighted during the demonstration and not provided in the Block Release. During this evaluation session, members of the LUG provided feedback.

A final Block Release evaluation period was held in mid-June 2002 at Hurlburt Field. Inputs from users who had participated in at least two of the three Block Release evaluation sessions were collected through a ratings-based questionnaire. The primary purpose of this final data collection period was to provide more experienced users an opportunity to consider their six-month experiences with LOCIS and assess its capability as a whole. A secondary objective was to collect preliminary data related to the set of exit criteria established by AFRL/HESR. These exit criteria will become the main area of focus for data collection during the LOCIS field test to be conducted upon completion of Spiral 3.

This report documents findings of the data collection sessions conducted at Hurlburt Field and during the Spiral 2 Demonstration. It also documents results obtained during the final evaluation period and users' perspectives with respect to the LOCIS exit criteria.

B.2.1 Data Collection

B.2.1.1 Block Release Data Collection Approach

Members of the LOCIS Operational Architecture IPT conducted a series of Block Release training sessions in November 2001. Potential users of the Block Release were identified and invited to participate in the November training session. After receiving training, these new LOCIS users were encouraged to interact with LOCIS on a regular basis. The two-month period between training and the initial data collection session in January 2002 afforded new users additional time in which to familiarize themselves with all of the features provided in the Block Release. Three Block Release evaluation sessions were conducted at Hurlburt Field. The initial evaluation session was conducted 22-25 January 2002. The second and third sessions were conducted 19-22 February 2002 and 19-22 March 2002, respectively. Of the 33 users trained on LOCIS in November, 17 participated in the evaluations. Additionally, 8 of these 17 participants provided feedback during two or more evaluation sessions, and 6 of these 17 individuals participated in all three sessions.

During each month's data collection effort, members of the Human Factors team conducted several small group sessions. Members of the Operational Architecture IPT provided functional support. In each small group session, one to four individuals were interviewed on various "usability" aspects of a set of pre-selected LOCIS features. These aspects included accessibility of LOCIS data, ease of use, and usefulness of LOCIS as both an information provider and decision support tool. User feedback specific to each feature was recorded. Users also provided subjective ratings on the features targeted for each month's evaluation session. (Note that the number of participants in each small group session was necessarily dictated by the availability (work schedule) of each participant.)

In considering accessibility of LOCIS data, users provided their perceptions on the accessibility of the LOCIS web site (i.e., log on procedures). With respect to "ease of use" issues, users provided feedback on the extent to which content and format of information displays is easily interpreted, as well as on the ease with which information is located via the main menu bar, browser tool, and pull-down lists. Users also provided their perceptions on the ease with which customizable user settings are adjusted.

In considering the usefulness of LOCIS as a decision support tool, users assessed the extent to which LOCIS information displays (1) maintain situation awareness, (2) provide information relevant to job requirements, and (3) provide timely information. Users also assessed the extent to which LOCIS customization features helped to "push" them the right information.

As a part of each Block Release evaluation session, the evaluation team, led by AFRL/HESR, conducted an out-brief with Hurlburt leadership.

During the final Block Release evaluation period conducted in mid-June, users who had participated in at least two of the three evaluation sessions were asked to complete a questionnaire. A technical point of contact at Hurlburt identified an appropriate set of users and requested inputs from them. Completed questionnaires were delivered to AFRL/HESR.

The following features were targeted for Block Release evaluation:

a. User Interface Framework
b. Information Displays
c. Customization
d. LOCIS Pop-Up Windows
e. Automated Notifications

Included in the User Interface Framework were log on procedures and navigation. Information Displays included Schedule, Status, and Supply views. Customization included threshold settings, display options (for customization of individual LOCIS views), the workspace builder, and user profile settings. LOCIS Pop-Up Windows included the drill-down information displayed upon a user's selection of aircraft icons, sortie and maintenance blocks, and aircraft availability threshold messages. Automated Notifications included the alert/warning indicator (displayed in the menu bar and activated when an aircraft availability threshold is violated), the alert/warning log, and the general message log.

B.2.1.2 Spiral 2 Data Collection Approach

A single evaluation session, conducted by members of the Human Factors team, was held in conjunction with the Spiral 2 Demonstration held at BAE SYSTEMS. Members of the Operational Architecture IPT provided functional support. During this evaluation session, eight members of the LUG provided feedback on the features demonstrated during the Spiral 2 Demonstration. As in the Block Release evaluation, user data was collected within the context of small group interview sessions. The eight LUG members were divided into two groups of four individuals each, and two separate interview sessions were conducted in parallel. One of the parallel sessions focused on navigation (User Interface Framework), schedule and supply views (Information Displays), and the workspace builder (Customization), while and the other focused on status views (Information Displays), threshold settings (Customization), LOCIS notifications (Automated Notifications), and the *Tools* link (User Interface Framework). The Human Factors team conducted two parallel sessions in the morning of 30 April and two parallel sessions in the afternoon.

As in the small group sessions conducted during Block Release data collection activities, each user group was interviewed on various usability aspects of the set of LOCIS features pre-selected for the session. LUG feedback specific to each feature was recorded. LUG users also provided subjective ratings on targeted LOCIS features.

B.2.2 LOCIS Block Release Evaluation Findings

B.2.2.1 Summary of LOCIS Block Release Data Collection Sessions: 22-25 JAN 02

Two members of the Human Factors team and one member of the Operational Architecture IPT interviewed 8 users out of the 33 trained in November 2001. Of these eight users, five had logged back on to LOCIS at least once after being trained.

The focus of this evaluation trip was to collect feedback on log in/out procedures and on LOCIS navigation features. In general, users provided positive comments about navigation and data presentation. Users considered the log in procedure (e.g., typing LOCIS URL, selecting a *Favorites* link, selecting a LOCIS desktop icon) to be straightforward. One user established his browser home page to be the LOCIS log on page.

The LOCIS evaluation team encouraged Hurlburt participants to continue their use of LOCIS so they would be prepared to provide another set of comments during its second trip in mid-February.

B.2.2.1.1 General Comments from Users

Some users had built additional workspaces (i.e., in addition to those built during training sessions). These new workspaces were used primarily to monitor status data—primarily at the beginning of the day—to provide a "heads up" on what would need attention throughout the day.

Users indicated that "getting accustomed to" the data presentation provided in LOCIS played a big part in their levels of use. In other words, they are accustomed to using the local C2 database and are comfortable with it. LOCIS is still an unknown product, and users need continued assurance that its reliability will be consistent with the tools they use now. They need to establish a "comfort zone" (and/or know that their leadership is also using LOCIS).

Users suggested a few additional data items from the C2 database that might be included in LOCIS recap and supply views.

B.2.2.1.2 General Comments from Hurlburt Leadership

An out-brief with the 16 SOW MXG/CC was conducted on 24 January 2002. LOCIS received strong support from 16 SOW leadership. The MXG/CC believes the features currently available in the LOCIS Block Release are useful. He identified four issues that, once addressed, would help motivate users to consider LOCIS as a useful work tool. (Other Hurlburt users also raised these issues during their interview sessions.)

a. Clicking on the "x" in the upper right corner of a LOCIS web page as a means of logging out continues to be a problem. As we have been made aware, "x"-ing out does not result in a log out; however, users are unaware that when they "x" out, they have not logged out. Currently, they have no way to recover from an "x" out. Note that "x"-ing out of a web page is a common technique and among most users is done by habit.

b. Eliminating the "time out" feature would be helpful. Many users would like to keep LOCIS up and running throughout the day, without being required to repeatedly log on after the time out occurs.

c. Providing a re-size capability allowing users to fit LOCIS pages so that they completely fill the display area of the monitor (i.e., "maximize") would be a definite advantage. The 16 SOW LG, for example, uses a flat panel 17" monitor. Currently, the LOCIS pages use only approximately 60% of the real estate provided by his monitor, and the pages cannot be expanded.

d. Improving the notification users receive when an agent is not running (to ensure they are made aware that respective data are not necessarily valid) would also be advantageous.

B.2.2.2 Summary of LOCIS Block Release Data Collection Sessions: 19-22 FEB 02

During this evaluation, members of the Human Factors team and Operational Architecture IPT interviewed 12 users. (Five of these individuals provided feedback during the January

evaluation.) In addition to these 12 users, the LOCIS team spoke with Hurlburt leadership (16 SOW MXG/CC and MXG/CD).

B.2.2.2.1 General Comments from Users

By and large, users like the visualization features designed into LOCIS. Evaluators still received comments about the scrolling requirements for schedule and status displays. If some means of allowing users to compress/collapse schedule displays (and reduce horizontal scrolling requirements) could be devised, many of the negative comments received about scrolling could be addressed.

Some additional (minor) "tweaks" to the Recap display were suggested. Settings to adjust "alert" and "warning" levels for the A/C availability threshold appear to be confusing a number of users. Specifically, users expressed some confusion about what the levels actually are once they are set. Some type of print capability was suggested by a number of users. Several users strongly encouraged the LOCIS team to begin training Pro Supers.

B.2.2.2.2 General Comments from Hurlburt Leadership

Again, in general, feedback was positive. Both the 16 MXG/CC and MXG/CD had favorable comments. The 16 MXG/CC indicated that if he could make changes to LOCIS, he would make two changes:

a. Change the default dimensions of each pop-up window to be "maximized."

b. Address the "x" out problem for pop-up windows. Currently, when pop-ups are "x"-ed out (rather than closed with the "close" button provided in the window), their corresponding icons accumulate along the lower tool bar.

B.2.2.3 Summary of LOCIS Block Release Data Collection Sessions: 19-22 MAR 02

During this evaluation, members of the Human Factors team and Operational Architecture IPT interviewed 11 users. Of these 11, three were individuals not interviewed during the two previous trips. An out-brief with the 16 SOW MXG/CC was conducted on 21 March.

Data collection interviews focused on the following:

a. Supply views
b. Unit-level At-a-Glance views
c. Workspace builder
d. Alerts/warnings (including the A/C availability threshold pop-up window)

Again, comments were positive, although widespread use of LOCIS is still rather low. Approximately three to four individuals (including 16 MXG/CC) log on to LOCIS on a daily basis.

B.2.2.3.1 General Comments from Users

The recent updates BAE SYSTEMS incorporated into the *All MICAPs* views were well received. Users liked the changes. (Specifically, "Urgency" and "Status" fields were added, and the two "EDD" fields were replaced with a single "EDD" field). Users provided a few recommendations for additional data for *All MICAPs* and *Supply Drivers* views.

Users like the unit-level *At-a-glance* views. The geographic layout is useful—particularly for MOC users. Showing all A/C parked in specific locations (rather than displaying only those A/C belonging to a respective unit) would be helpful.

The workspace builder is useful, and users like having the ability to integrate different types of data into a single "window". However, they would also like having control of individual panels making up a workspace. That is, making each panel an independent entity would allow users greater flexibility in controlling their workspace views (e.g., for resizing purposes)—especially for four-pane workspaces in which dimensions of individual panels are reduced significantly. Users also suggested allowing the addition of a single view to the list of workspaces (in addition to the two-pane and four-pane options provided in the wizard). Such a feature would provide users a "favorites" list and would allow them to access these favorites without using the navigation bar.

Allowing users to monitor threshold levels was regarded as useful, although given current deployed conditions, the A/C availability threshold is not particularly meaningful. Evaluators received a few suggestions for additional thresholds (e.g., ETIC "busts" or EDD updates).

B.2.2.3.2 Comments from Hurlburt Leadership

Feedback from the 16 MXG/CC was positive. The inclusion of additional (key) data in the icon rollovers was suggested. (These critical data items are currently included in A/C icon drill down.) Preference is to see these critical data items (e.g., ETIC, driving discrepancy, TO and land times) as part of the rollover—without having to drill down to access them.

The 16 MXG/CC would also find a display showing flyers scheduled across the wing (i.e., a wing-level flying schedule) useful.

There is some interest in providing an LOCIS intro briefing and/or training to the OG side of the house.

B.2.2.4 Block Release Findings: Details

This section offers further details on the feedback collected from users during the three Block Release evaluation sessions.

B.2.2.4.1 User Interface Framework

Users indicated that the LOCIS interface was easy to use and that navigation within LOCIS was straightforward. No clear preference for either navigation technique (pull-down lists versus

organization chart accessible via the browser tool) was evident. That is, the use of pull-down lists versus use of the browser tool was equally divided among users interviewed. Some users believed pull-down lists were awkward to use. Organizations at lower levels in the hierarchy cannot be directly selected from the pull-down lists unless corresponding higher-level organizations have already been selected from pull-down lists. In other words, to select a view for a given organization at level *L*, a user must first select all corresponding higher-level organizations linked to *L*. For example, to access the daily flying schedule for the 15 AMU (unit level), the user must first select 16 MXG (group level) and 16 AGS (squadron level) from the pull-down lists. (The 15 AMU is one of the three unit-level organizations comprising the 16 AGS, and the 16 AGS is a squadron-level organization within the 16 MXG.) Users suggested that any organization, at any hierarchical level, be accessible at any time.

Users also commented on the "look and feel" of the blue page tabs incorporated in LOCIS. Although tab labels were meaningful, some users suggested enhancements to the "look and feel" of LOCIS tabs (e.g., modifying tab appearance to resemble "folder-type" tabs). Specifically, users suggested that the hyperlink capability associated with each tab was not readily apparent. (Insufficient contrast between the light blue color of the tab and the background color of LOCIS pages contributed to this deficiency.) In other words, as displayed on a LOCIS page, tabs were not immediately recognizable as active links. Without training, users might not recognize LOCIS tabs as active links. One user suggested modifying tab appearance to resemble "folder-like" tabs.

Users also agreed that a "single log on" approach (i.e., accessing LOCIS via log on/password entry to AF Portal) was desirable but acknowledged that sensitivity of the data provided through LOCIS might warrant some type of additional password protection.

Users employed a number of different log on techniques—specifically, inclusion of LOCIS URL among the list of *Favorites* (Internet Explorer), manual entry of LOCIS URL at each log on, inclusion of LOCIS URL to *My Links* (AF Portal), and specifying the LOCIS log on page as the browser home page.

During all evaluation sessions, users expressed the need for a print capability.

In addition to offering feedback during the small group interview sessions, users also provided a series of subjective ratings specific the user interface framework. Each rating was based on a five-point scale. Results from the subjective ratings portion of the evaluation are summarized in the following tables. Each table reports the number of users assigning a given rating.

The LOCIS web site was				
1 *Easy to Access*	2	3	4	5 *Not at all Easy to Access*
7	0	0	1	0

When using the browser tool, the desired organizational level was				
1 *Easy to Specify*	2	3	4	5 *Not at all Easy to Specify*
5	3	0	0	0

When navigating within LOCIS, I preferred using the browser tool over the drop-down lists.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
0	1	5	1	1

When using the menu bar, desired categories of information (e.g., Status, Schedule) were				
1 *Easy to Locate*	2	3	4	5 *Not at all Easy to Locate*
6	2	0	0	0

As indicated by the subjective data, the ease of use attributed to the user interface framework—including navigation, accessibility to the LOCIS web site, and locating desired information—was high. With respect to navigation technique (i.e., browser tool versus pull-down lists), most users indicated no preference for one over the other. On the other hand, two users tended toward a preference for pull-down lists, and one user tended toward a preference for the browser tool.

B.2.2.4.2 Information Displays

In general users placed a high value on the visualization techniques (e.g., color coding, geographic layout of unit-level aircraft status views, timeline format for schedule data) employed in LOCIS. Specifically, users perceived the geographic layout applied in unit-level status displays to be useful—particularly for MOC users. Some users identified a need to view projected schedule data, in addition to daily schedule data. Specific projected periods of time (i.e., 72 hours or a week in advance) were suggested. On the other hand, other users preferred having an option for a user-specified period of time.

The *All MICAPs* view was revised in accordance with user feedback collected during the second evaluation session. Specifically, two fields ("Urgency" and "Status") were added to the *All MICAPs* table. In addition, the two "EDD" fields (intended to allow users to track original and current (updated) estimated delivery dates) were replaced with a single "EDD" field. This single field is intended to indicate current EDD (and will be updated as EDD is updated).

Scrolling requirements (particularly horizontal scrolling requirements) for the wing-level status and schedule views were regarded as "annoying." (Users did indicate their preference for vertical scrolling versus horizontal scrolling.)

Users found the *Data Sources* view, accessible from the *Tools* link, to be a useful means of verifying the timeliness of LOCIS data.

Results from the subjective ratings portion of the evaluation are summarized in the following tables. Each table reports the number of users assigning a given rating. In some instances, ratings solicited in the February evaluation sessions were solicited once again in the March sessions. In this manner, the LOCIS team could assess the extent to which subjective ratings on

the usefulness of LOCIS information displays changed between February and March—as users became more experienced with LOCIS capabilities. (Note that while some of the February participants also returned for the March evaluations, not all returned to provided feedback in March.) Repeated ratings are identified as such.

In general, users rated schedule, status, and supply views as "easy to understand". When considering the extent to which LOCIS information displays supported job requirements, all of the March participants agreed (indicated via a rating of *1* or *2*) that information displays supported tasks required by their jobs. The February data, however, indicates a lower percentage of participants believed that information displays supported job tasks.

Information provided in LOCIS schedule displays was				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
4 *	6*	1*	1*	0
8	1	2	0	0

* Data collected during the 19-22 February 2002 sessions. All other ratings were collected during the 19-22 March 2002 sessions.

Information provided in LOCIS status displays (16 MXG, 16 AGS) was				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
7	5	0	0	0

Information provided in LOCIS status displays—i.e., geographic layout displays for 4, 15, 16 AMU (16 AGS) was				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
8	3	0	0	0

Information provided in LOCIS supply displays was				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
7	4	0	0	0

LOCIS information displays supported tasks required by my job.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
2*	5*	4*	1*	0
5	6	0	0	0

* Data collected during the 19-22 February 2002 sessions. All other ratings were collected during the 19-22 March 2002 sessions.

B.2.2.4.3 Customization

As one means of creating customized workspaces—and integrating different kinds of data into a single work area—the Workspace Builder was viewed as a useful tool. Users agreed that having the flexibility to place multiple views into a single "space" allowed them to build an information display that could provide a meaningful overview of current conditions. Users suggested including a single-view workspace into the builder, in addition to the two-pane and four-pane workspaces provided as options. Given the option of including single-view workspaces to their list of customized workspaces, users could go directly to their favorite (single) views without having to navigate with the main menu bar.

Users expressed a desire for greater flexibility in controlling the contents (data elements) displayed in individual views. Their suggestion was to provide options for turning on (or off) any data field displayed in a given view.

For displaying schedule data, users preferred view options allowing them to display the longest "window" of time with respect to current time. Consequently, the typical display option selected for the schedule timeline was "±12 hours."

Results from the subjective ratings portion of the evaluation are summarized in the following tables. Note that each table reports the number of users assigning a given rating.

In general, users rated LOCIS customization features positively, although of the 12 users who considered customization as a whole, 4 neither strongly agreed, nor strongly disagreed that such features helped to "push" them the right information. The Workspace Builder—specifically, its ability to "push" users the right information and the manner in which it leads users through the process of creating customized workspaces—received positive ratings. Of the 11 users who rated customization features, 10 perceived the threshold settings to be easily adjustable.

User customization features helped to "push" the right information to me.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
4	4	4	0	0

Threshold settings were				
1 *Easy to Adjust*	2	3	4	5 *Not at all Easy to Adjust*
6	4	1	0	0

The Workspace Builder helped to "push" the right information to me.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
7	3	1	0	0

The process of creating customized workspaces was straightforward.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
8	1	1	1	0

B.2.2.4.4 LOCIS Pop-Up Windows

While users found the detailed data contained in pop-up windows (displayed as a result of a drill-down action) to be appropriate, they suggested that some of the more critical elements be included as part of the rollover data currently associated with aircraft icons, sortie blocks, and maintenance blocks. Providing this additional rollover information would reduce the need for users to perform many of the drill-down actions currently required for retrieval of critical data.

Users suggested that LOCIS designers revisit the default dimensions specified for pop-up windows. The suggestion was to automatically adjust window dimensions such that match the amount of data displayed and eliminate (or minimize) the need for scrolling.

Results from the subjective ratings portion of the evaluation are summarized in the following table. The table reports the number of users assigning a given rating. Ratings specific to the extent to which pop-up windows supported job tasks were solicited in both the February and March evaluation sessions. (Again, while some of the February participants also returned for the March evaluations, not all returned to provided feedback in March.)

Information provided in drill-down pop-up windows supported tasks required by my job.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
6*	1*	5*	0	0
5	6	0	0	0

* Data collected during the 19-22 February 2002 sessions. All other ratings were collected during the 19-22 March 2002 sessions.

When considering the ability of information contained in pop-up windows to support required job tasks, user ratings differed between February and March. Specifically, all of the March participants agreed (indicated by a rating of *1* or *2*) that pop-up information supported tasks required by their jobs. The February data, however, indicates users were less inclined to agree that pop-up information supported job tasks.

B.2.2.4.5 Automated Notifications

Users believed the aircraft availability threshold would be most useful under non-deployed conditions—when the majority of Hurlbut aircraft are on site. They also identified additional paramctcrs that would be useful to monitor—specifically, thresholds allowing users to be alerted to ETIC "busts" and EDD bumps (for MOC users).

For the General Message Log, users suggested a set of canned messages.

Results from the subjective ratings portion of the evaluation are summarized in the following table. This table reports the number of users assigning a given rating.

Information provided in the Alert/Warning Message Log was.				
1 *Useful in Informing me of Current Conditions*	2	3	4	5 *Not at all Useful in Informing me of Current Conditions*
3	3	4		1

When assessing the usefulness of message log information in maintaining situation awareness, users expressed some level of doubt. Of the 11 who rated the quality of Alert/Warning Message Log information, 4 users were unsure of its usefulness, and 1 user found it to be "not at all useful."

B.2.2.5 Final Block Release Evaluation

The questionnaire developed for the final evaluation period consisted of nine questions designed to capture users' subjective ratings of LOCIS navigation features, information displays and pop-up windows, customization features, and notifications. The intent of this particular evaluation was to focus users' assessments on LOCIS as a "complete package" (i.e., to assess a set of capabilities, rather than the content and format of individual information views or pop-up windows). Consequently, the ratings designed for the final evaluation were more general in nature than those developed for each of the monthly evaluation sessions. Each rating was based on a five-point scale, and results are summarized in tables to follow. Each table reports the number of users assigning a given rating.

In addition to addressing LOCIS capabilities, the questionnaire also addressed LOCIS' potential as an operational support tool. Questions developed for this portion of the questionnaire were designed to capture preliminary data on the LOCIS exit criteria established by AFRL/HESR. These exit criteria have been defined as follows.

a. Reduce the time to re-plan during a crisis-action contingency by 20%.
b. Reduce staff hours to produce capability and historical reports by 25%.
c. Reduce the time required for an assessment of wing/unit level capability by 25%.

Eleven users completed the questionnaire during the final evaluation period. To provide evaluators with information on users' experience levels, the number of times a user had logged on to LOCIS since January 02 was recorded on his respective questionnaire. This number ranged from 3 to more than 250, and two distinct user groupings were immediately evident. A small group of users had logged more than 60 LOCIS sessions since January, and a larger group of users had logged a maximum of only 10 sessions. Consequently, each user's experience level was defined in terms of one of these two groups. The more experienced users were those who logged more than 60 LOCIS sessions (Group A), while the less experienced users (Group B) had logged no more than 10 sessions. Four users were identified as Group A users, and seven were assigned to Group B.

Because of the large discrepancy between the number of sessions logged by Group A users and those logged by Group B users, the Human Factors team believed experience level could have some influence on user responses, and any experience-based differences should be identified. Consequently, user data are reported according to experience level, where ratings collected from Group A users are reported separately from Group B ratings. In this manner, any differences between the two groups can be readily identified.

B.2.2.5.1 Navigation

Users' perceptions regarding the straightforwardness of LOCIS navigation tasks are summarized in the following table.

	Navigation within LOCIS is a straightforward task.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	3	1	0	0	0
Group B	2	4	1	0	0

As indicated through the summary data, regardless of experience level, most users found navigation within LOCIS to be straightforward.

B.2.2.5.2 LOCIS Information Displays and Pop-Up Windows

Through a series of four ratings, users provided feedback on the extent to which LOCIS displays and detailed drill-down information maintained situation awareness. Specifically, users were asked to rate the following:

a. How well LOCIS' real time data facilitated an understanding of current conditions
b. The extent to which LOCIS visualization techniques helped to identify critical issues
c. The ease with which information displays were interpreted
d. The value of the detailed information provided as a drill-down capability.

User inputs are summarized in the following four tables.

	The real-time nature of LOCIS data allows users to maintain an understanding of current conditions.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	2	2	0	0	0
Group B	2	4	1	0	0

	LOCIS visualization features (e.g., timeline formats for schedule data, color-coded aircraft icons, geographic layouts) help to highlight issues requiring attention.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	3	1	0	0	0
Group B	3	3	1	0	0

	Information provided in status/schedule/supply displays and pop-up windows is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group A	3	1	0	0	0
Group B	5	1	1	0	0

	Detailed drill-down information accessible from LOCIS status, schedule, and supply views adds value to the data contained within those views.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	3	1	0	0	0
Group B	4	2	0	1	0

The ratings data indicate that most users, regardless of experience level, believed LOCIS did a good job of supporting situation awareness, although one less experienced user was dissatisfied with the usefulness of drill-down data. When considering the ability of LOCIS' real time data and visualization techniques to help identify critical situations, one Group B user indicated, through a rating of *3*, no specific benefit to either of these features. Similarly, when considering the ease with which status, schedule, and supply data are interpreted, one user indicated no specific advantages of the presentation features provided in LOCIS displays and pop-up windows.

B.2.2.5.3 Customization Features

Through a series of three ratings, users assessed LOCIS' primary customization features—specifically, the Workspace Builder and the *Options* button available in LOCIS information views. (The *Options* button allows users to change the look and feel of individual information views.)

	The Workspace Builder is useful because it allows users to integrate information most critical to them.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	1	2	1	0	0
Group B	1	2	4	0	0

	Creating customized workspaces with the LOCIS Workspace Builder is straightforward.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	2	2	0	0	0
Group B	1	3	2	0	1

	In allowing users to customize LOCIS information displays, the *Options* feature offers				
	1 *Sufficient Flexibility*	2	3	4	5 *Insufficient Flexibility*
Group A	3	0	1	0	0
Group B	1	3	2	1	0

Group B users rated LOCIS customization features less favorably than they rated navigation and information display/pop-up window features. With respect to the three customization aspects evaluated, the Workspace Builder's usefulness in allowing users to integrate critical information was rated least favorably. Three of the seven Group B users found the task of creating workspaces to be less than straightforward, and three Group B users were not convinced the flexibility of the *Options* feature was sufficient to support information display customization. In comparing customization feature ratings between Group A and Group B, a larger proportion of Group B users were dissatisfied with LOCIS customization features. The less favorable inputs from Group B users might be attributed to their lower experience levels. With more extensive LOCIS interaction, these ratings might be improved.

B.2.2.5.4 LOCIS Notifications

Users were asked to evaluate the usefulness of LOCIS notifications in maintaining situation awareness. Of specific interest in this evaluation was the Alert/Warning Message Log.

	Information available in the Alert / Warning Message Log is useful in keeping users aware of current conditions.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group A	2	0	2	0	0
Group B	2	3	2	0	0

The ratings data indicate that slightly more than 33% of users expressed some doubt that the Alert/Warning Message Log was useful in maintaining situation awareness. In comparing ratings between Group A and Group B, a larger proportion of Group A users expressed concern over the usefulness of the Alert/Warning Message Log.

B.2.2.5.5 LOCIS as a Support Tool

The intent of the final portion of the questionnaire ("LOCIS as a Support Tool") was to collect preliminary data on the three LOCIS exit criteria established by AFRL/HESR. To capture this type of feedback, the Human Factors team developed the three two-part questions stated below.

a. Do you believe LOCIS could reduce the time required to re-plan during crisis-action contingencies?

   If yes, by what percentage do you estimate re-planning time could be reduced?

b. Do you believe LOCIS could reduce the time required to generate capability and historical reports?

   If yes, by what percentage do you estimate report generation time could be reduced?

c. Do you believe LOCIS could reduce the time required for assessing wing- and unit-level capability?

If yes, by what percentage do you estimate assessment time could be reduced?

A summary of responses to these questions is recorded in the following tables. Users' estimates of potential improvements due to LOCIS are provided in parentheses in the *Yes* columns. Data are reported according to experience level. Note that not all users responded to each question, nor did all offer estimates when responding with a *yes*.

	Do you believe LOCIS could reduce the time required to re-plan during crisis-action contingencies? (If yes, by what percent?)	
	Yes	*No*
Group A	3 (20-30%, 25%, 30%)	1
Group B	4 (25%, 20%, 20%)	2

	Do you believe LOCIS could reduce the time required to generate capability and historical reports? (If yes, by what percent?)	
	Yes	*No*
Group A	1 (50%)	3
Group B	4 (20%, 25%)	2

	Do you believe LOCIS could reduce the time required for assessing wing- and unit-level capability? (If yes, by what percent?)	
	Yes	*No*
Group A	2 (20%, 15%)	2
Group B	6 (10%, 25%, 25%, 40%)	1

With the exception of LOCIS' ability to support the preparation of capability and historical reports, most users believed LOCIS could provide useful support—specifically, in reducing the time required for re-planning activities and assessments of wing- and unit-level capability. When considering LOCIS' potential to support capability/historical report generation, the ratings were split. Five users believed LOCIS could save time in generating reports, while five believed that no time savings could be expected.

The three exit criteria establish the levels by which AFRL/HESR expects LOCIS to reduce the time required for re-planning efforts, generating capability and historical reports, and assessing wing- and unit-level capability. Specifically, reductions of 20% (re-planning), 25% (reports), and 25% (capability assessments) are expected. All estimates of expected reductions in conducting re-planning efforts were at least 20%. When considering LOCIS support of report generation tasks, one Group A user estimated a 50% reduction in task performance time; however, the user qualified this estimate by stating it could only be realized with the addition of a LOCIS print capability. Two of the four Group A users did not believe LOCIS could save time in assessing wing- and unit-level capabilities. (The reason for one of these *no* responses was due to LOCIS' reliance on Hurlburt's local C2 database.)

In reviewing the exit criteria feedback—in particular, user estimates of time savings that could be realized through LOCIS—note that it is only preliminary and is <u>not</u> based on actual user

performance data. That is, the estimates do not reflect comparisons of current task performance times (for re-planning, report generation, and capability assessment tasks) against LOCIS-supported task performance times. Note, too, that most of the estimates were provided by less experienced users.

B.2.3 Spiral 2 Demonstration Evaluation Findings

Many of the comments gathered during the Block Release evaluation sessions were reiterated during the Spiral 2 evaluation sessions. Some of these comments are repeated in the following section as a means of validating Block Release data; however, the intent of this section is to document user feedback not provided during the course of the Block Release evaluation.

B.2.3.1 Spiral 2 Data Collection Sessions

No significant changes were recommended for any of the views evaluated, although several suggestions were made in terms of "tweaking" or refining individual views by adding information or reformatting existing information. The addition of information generally involved adding data to rollovers, or adding a column to an existing table. Other changes could be accomplished by hyperlinking existing text to existing pages. Other suggestions included making existing text more prominent by incorporating boldfaced or enlarged text.

B.2.3.1.1 User Interface Framework

In considering the navigation options provided in LOCIS, LUG members expressed no preference for either the pull-down lists or the browser tool; however, some members preferred that only one navigation technique be provided in LOCIS (i.e., provide a pull-down list option or a browser tool option but not both).

To enhance the "interpretability" of the labels assigned to main menu links, LUG members suggested providing a brief definition or description of the information a user might find underneath each link. This definition could be included as part of a rollover for the link. Along these same lines, members also suggested providing, for each category link, a list of the respective tab links—e.g., a rollover for the *Schedule* link (unit level) would list "All Aircraft", "Flyers", "Maintenance", and "Launch Sequence."

LUG members indicated that Fleet Status (accessible via the *Tools* link) was not a high priority requirement, although it may be more relevant to ACC than AFSOC. Users also indicated that the information provided might already be present in MERLIN and/or ALIA.

As in the Block Release evaluation sessions, participants provided a series of subjective ratings specific the user interface framework. Results are provided in the following tables. The same five-point rating scale was applied; however, in some cases, questions were modified slightly to increase their relevance for LUG members. Results from the subjective ratings portion of the evaluation are summarized in the following tables. Each table reports the number of users assigning a given rating.

To navigate within LOCIS, I prefer the browser tool over the drop-down lists.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
4	1	3	0	0

In the menu bar, desired categories of information (e.g., Status, Schedule) are				
1 *Easy to Locate*	2	3	4	5 *Not at all Easy to Locate*
3	4	0	1	0

Obtaining desired fleet status information (accessible via the *Tools* link) is straightforward. *				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
1	3	2	1	0

* One user did not provide a rating.

As indicated by the subjective data, the ease of use attributed to the main menu—specifically, locating desired categories of information—was high, although one LUG member found this information somewhat more difficult to locate than did the remaining members. When considering the accessibility of data available through the *Tools* link, however, participants were less inclined to offer a high ease of use rating. Specifically, four of seven participants considered the task of obtaining desired fleet status information to be straightforward—with only one of these four strongly agreeing that the task was straightforward. With respect to navigation technique (i.e., browser tool versus pull-down lists), five of eight participants tended toward a preference for the browser tool. The remaining three participants expressed no clear preference.

B.2.3.1.2 Information Displays

For status views, LUG members suggested making the MC summary statistics more prominent by emphasizing them through bold-faced text or moving them to the top of each Unit or Squadron window. Also, the squadron label and MC rate text were suggested as potential hyperlinks. For example, at the wing level, clicking on the label identifying a squadron or unit would take the user to the squadron or unit-level screens. By clicking on MC rate text, the user would be taken to more detailed data for MC rate. Identification of "hangar queen" status was suggested. LUG members indicated the importance of knowing which aircraft have been out of service for a lengthy period of time. Members pointed out that in addition to knowing hangar queen status, an MXG may simply want to know which aircraft are "problem children" from the standpoint of a lengthy NMC period. LUG members suggested including as much information as possible about transient and off site aircraft. If information is not available, they suggested "graying out" the aircraft. The overall philosophy was to provide information about each and every aircraft on the facility, regardless of its origin or owning agency.

LUG members indicated that if possible, scrolling should be eliminated. If scrolling cannot be completely eliminated, vertical scrolling is more acceptable than horizontal scrolling.

In assessing the view depicting pilot certification data, LUG members could not confirm its usefulness for OG-level decision making. A suggestion was made to add maintainer certification status in this area.

In considering LOCIS flying schedule views, LUG members suggested that higher headquarter missions be identified as such (i.e., distinguishing them from "regular" missions). The launch sequence view (not provided as a Block Release capability) was well received, although some members questioned the need for two separate views—suggesting the integration of launch sequence and flying schedule data into a single view. One suggestion for merging launch sequence and flying schedule data was to add the appropriate flying schedule data to the current launch sequence view. Another suggestion was to link the launch sequence graphic for a specific line number to its respective sortie block. In other words, launch sequence information would be provided as part of the drill-down information linked to sortie blocks. Members commented that to be completely proactive in monitoring flying schedules, users must not only be alerted to those instances in which an ETIC exceeds a take off time, they must also be notified of any delays in the launch sequence. In other words, a more proactive approach might be to trigger notifications (alerts) based on launch sequence delays.

When asked to compare the merits of the original *All MICAPs* view to the recently revised *All MICAPs* view (current Block Release version), some members acknowledged that the "Original EDD" field provided in the original *All MICAPs* table (and not included in the Block Release table) would be particularly meaningful for supply users.

Results from the subjective ratings portion of the evaluation are summarized in the following tables. In general, most LUG members rated the information depicted in schedule and supply views as "easy to understand."

Information provided in LOCIS schedule displays is				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
5	1	1	1	0

Information provided in LOCIS supply displays is				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
6	1	1	0	0

Information provided in LOCIS status displays (16 MXG, 16 AGS) is				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
4	3	1	0	0

Information provided in LOCIS status displays—i.e., geographic layout displays for the 4, 15, and 16 AMU—is				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
3	3	2	0	0

B.2.3.1.3 Customization

LUG members found the Workspace Builder to be a useful tool—suggesting the most useful multi-view workspaces would be those in which the individual views making up the workspace represent aggregations of data (i.e., higher-level data summaries). Because dimensions of the views combined into a single workspace are necessarily reduced, members suggested that the most meaningful representation of the data associated with each individual view would be an "abstract" (summary) of that data. While LUG members agreed with Block Release users that a single-view workspace would be a useful option to include in the builder, they also suggested including a triple-view workspace option. One member provided an interesting twist to the concept of multi-view workspaces by suggesting a "picture in a picture" feature. Another member suggested that the workspace builder concept be expanded to a "view builder" concept in which views are built up from individual data elements via queries.

Members expressed some confusion when asked whether the pointer on the threshold slider bar represented a red or yellow level. LUG members suggested color coding the slider pointers to indicate whether a selected number would be assigned a red or yellow level.

As reflected in the subjective data provided in the following tables, participants rated the Workspace Builder positively. Specifically, its ability to "push" users the right information and the manner in which it leads users through the process of creating customized workspaces—received positive ratings.

The Workspace Builder helped to "push" the right information to users.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
6	2	0	0	0

The process of creating customized workspaces is straightforward.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
6	2	0	0	0

Threshold settings are				
1 *Easy to Adjust*	2	3	4	5 *Not at all Easy to Adjust*
7	1	0	0	0

B.2.3.1.4 LOCIS Pop-Up Windows

In the discussion of thresholds (aircraft availability), LUG member identified MC rate as an important issue, and they indicated a desire to see more data indicating what is contributing to MC rate. For example, members suggested breaking down NMC rate into the components "supply," "maintenance," and "both." Members also suggested the addition of a threshold that would allow users to monitor "total possessed hours."

LUG members also expressed some concern that the drill-down information displayed when a *Recap* view aircraft icon is selected represents current (real-time) data, while the nature of recap data is inherently historical. Members suggested that displaying real-time data (the aircraft drill-down information) within the context of historical data (*Recap* view) is a potential source of confusion among users.

In general, most members believed the drill-down information accessible from schedule and supply views added value to schedule and supply data contained within those views. Specifically, seven of eight LUG participants agreed (indicated by a rating of *1* or *2*) that drill-down information added value to higher-level views.

Drill-down information accessible from LOCIS schedule displays adds value to schedule data.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
3	4	1	0	0

Drill-down information accessible from LOCIS supply displays adds value to supply data.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
4	3	0	1	0

Drill-down information accessible from LOCIS status displays adds value to status data.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
6	1	1	0	0

Drill-down information accessible from the Alert/Warning Message Log adds value to alerts and warnings.				
1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
4	3	1	0	0

B.2.3.1.5 Automated Notifications

In considering the message logs provided in LOCIS, users indicated that grouping notifications by "subject" seems appropriate, with an "action taken" category to indicate the status of the notification. The "green-yellow-red" color coding approach applied in the Alert/Warning Message Log caused some concern among LUG members, who felt that it could potentially confuse aircraft availability levels (green – OK, yellow – Warning, red – Alert) with aircraft status (green – FMC, yellow – PMC, red – NMC). In fact, several members erroneously confused the setting of an aircraft availability threshold level with aircraft status.

As indicated by the subjective ratings summarized in the following table, most users found the information available in the message log easy to understand.

Information provided in the Alert/Warning Message Log is				
1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
4	3	1	0	0

B.2.4 Human Factors Recommendations

Based on user feedback collected during Block Release and Spiral 2 Demonstration evaluations, the following human factors recommendations are provided. The Human Factors team suggests these recommendations be considered for future implementations of the LOCIS capability, including the Spiral 3 effort and any future block release versions. Recommendations are grouped according to the five features targeted for evaluation: User Interface Framework, Information Displays, Customization, LOCIS Pop-Ups, and Automated Notifications.

User Interface Framework

a. Address printing requirements.

b. Enhance the "look and feel" of LOCIS page tabs (i.e., to make them more recognizable as active links).

Information Displays

a. Address scrolling issues (particularly for wing-level status view and multi-view workspaces).

b. Fill any empty data fields displayed in Supply views.

c. Provide wing-level schedule data.

d. Show locations of all aircraft (in unit-level status views).

e. Identify design options for higher-level summary views of flying schedule, status, and supply data to accommodate constraints imposed by multi-view workspaces.

Customization

a. Provide additional information in rollovers.

b. Provide a single-view workspace as an option in the Workspace Builder—to provide more direct access to user "favorites"—and also provide a triple-view workspace option.

c. Allow users direct control of individual views contained within a workspace—specifically, allow "selection" and "resizing" of individual views.

d. Allow users to save format changes (e.g., supply views).

e. Re-examine the current approach for setting aircraft availability threshold levels.

LOCIS Pop-Ups

Adjust the default dimensions of pop-up windows—such that dimensions of a given window match the amount of data displayed and eliminate (or minimize) scrolling requirements.

Automated Notifications

Consider including additional thresholds (e.g., visualization of ETIC "busts" or EDD bumps).

B.3 LOCIS Spiral 3 Usability Evaluation Results

The LOCIS Spiral 3 Demonstration was held at Wright-Patterson AFB (AFRL/HESR) on 10 December 2002. In conjunction with the Spiral 3 Demonstration, AFRL/HESR hosted a usability evaluation on 10-11 December 2002. During evaluation sessions, LUG members provided feedback on selected capabilities of the LOCIS Spiral 3 implementation. Selected capabilities were those either newly implemented for Spiral 3 or modified from the Spiral 2 Block Release and Spiral 2 Demonstration versions of LOCIS.

The following table summarizes the capabilities targeted for the Spiral 3 usability evaluation.

Interface Feature	*Capability to be Evaluated*
User Interface Framework	• Navigation • Report Generator
LOCIS Information Displays	• Schedule Displays • Status Displays • Munitions Displays • "Print Screen"
Tools	• Forecasting Tool
LOCIS Notifications	• Threshold Settings • Alert and Warning Message Log
Customization	• Workspace Builder

The human factors data collection effort was led by GTRI and supported by UDRI. BAE SYSTEMS and AFRL/HESR provided functional expertise. A total of nine LUG members provided feedback. After completing a training session, LUG members were divided into two groups, and feedback was provided within the context of small group interview sessions. The data collection team was also divided into two groups (one led by GTRI and another by UDRI) so that two parallel evaluation sessions could be conducted. The GTRI data collection team captured feedback on the following features:

a. LOCIS Information Displays (Munitions Displays)
b. Tools
c. LOCIS Notifications

The UDRI data collection team captured LUG feedback on the following features:

a. User Interface Framework
b. LOCIS Information Displays (Status and Schedule Displays, "Print Screen")
c. Customization

The following paragraphs summarize the major findings of the Spiral 3 usability evaluation. In addition to offering feedback during the small group interview sessions, LUG members also provided a series of subjective ratings specific to the capabilities being targeted for the Spiral 3 evaluation. Each rating was based on a five-point scale. Results from the subjective ratings portion of the evaluation are included in the following sections.

B.3.1 Summary of LUG Comments

In general, LUG feedback on the capabilities implemented for LOCIS Spiral 3 was favorable. LUG members were impressed with the progress LOCIS has made since its earlier spirals.

B.3.1.1 User Interface Framework

B.3.1.1.1 Navigation

In general, LUG members found the navigation approach to be good. They also believed the organization chart icon displayed in the main menu worked well. LUG members made several recommendations for improving the "look and feel" of LOCIS links. Specifically, they suggested greater contrast between the links' text labels and the background color of the main menu. LUG members also suggested that the *Reports* link be located closer to the information display category links. They also recommended that the LOCIS tabs be modified to have a more "tab-like" look and feel. The LOCIS interface should provide a clear indication that a given tab has been selected (e.g., highlighted tab)—meaning that its respective view is currently displayed. (Currently, this indication is not always provided.)

The following table documents subjective ratings for the navigation approach implemented within LOCIS. Each table reports the number of users assigning a given rating.

	Navigating within LOCIS via the browser tool is straightforward.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	1	0	0	0
Group 2	1	3	0	0	0

B.3.1.1.2 Report Generator

It was difficult for participants to comment on the report generation feature because the demonstrated implementation depicted only limited capabilities. The report generator must allow for more reports than just the Daily Flyers and Recap.

The following tables document subjective ratings for the LOCIS report generation capability. Each table reports the number of users assigning a given rating.

	Navigating within LOCIS via the browser tool is straightforward.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	1	0	0	0
Group 2	1	3	0	0	0

	The report generator capability adequately satisfies the need to print LOCIS data.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	1	2	2	0	0
Group 2	0	1	1	1	1

	LOCIS-generated reports are sufficient to support maintenance stand-up meetings.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	1	1	3	0	0
Group 2	0	1	1	1	1

B.3.1.2 LOCIS Information Displays

B.3.1.2.1 Schedule

LUG members identified the importance of having access to *today's recap* information. Maintainers track aircraft throughout the day, particularly after each flight, to stay up-to-date regarding which aircraft are broken and for what reason. LOCIS must provide recap information after each go (set of line numbers), as well as yesterday's recap information already provided within LOCIS. A related issue is the need for maintainers to access Debrief Discrepancies on the Recap screen. LOCIS must include the reason for the *Alpha* landing code displayed on the Recap screen.

Users repeatedly emphasized the importance of knowing which tail numbers are scheduled to fly tomorrow. Two solutions were discussed: 1) an identifier on the aircraft icon to indicate the aircraft as a flyer for tomorrow; and 2) a "tomorrow at-a-glance" view similar to the existing status at-a-glance view depicting tomorrow's activities.

The existing scheduled maintenance information is not enough. Users want to see what maintenance has been scheduled for the week similar to their "checkerboards"—not just maintenance due dates.

The following tables document subjective ratings for LOCIS schedule displays. Each table reports the number of users assigning a given rating.

	Information provided in LOCIS schedule displays is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	1	4	0	0	0
Group 2	1	3	0	0	0

	Drill-down information accessible from sortie (blue) and maintenance (gray) activity blocks adds value to schedule data.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	2	2	1	0	0
Group 2	0	4	0	0	0

	Providing a single "snapshot in time" view for the *All Aircraft* and *Flyers* displays improves their usability.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	1	0	0	0
Group 2	0	4	0	0	0

	The *Scheduled Maintenance* display offers ready access to data that is currently difficult to consolidate.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	2	1	2	0	0
Group 2	0	3	1	0	0

B.3.1.2.2 Status

Users expressed a need for data on NMC aircraft, along with each aircraft's respective discrepancies and corresponding ETICs. A potential solution is to create a screen under status that includes: tail #, status, driving discrepancy, ETIC, JCN, Doc #, and EDD. A "nice to have" capability would be to link the 781A and K write-ups for the selected tail number. The "Summary Discrepancy Table" associated with the aircraft availability threshold (as depicted in the Spiral 2 demonstration and the LOCIS Block Release version implemented at Hurlburt) could satisfy this requirement.

The following tables document subjective ratings for LOCIS status displays. Each table reports the number of users assigning a given rating.

	The LOCIS wing-level aircraft status display allows a user to achieve a good top-level understanding of current wing conditions.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	1	0	0	0
Group 2	2	2	0	0	0

	The level of detail provided in the wing-level aircraft status display is				
	1 *Appropriate*	2	3	4	5 *Not at all Appropriate*
Group 1	3	2	0	0	0
Group 2	0	4	0	0	0

	Information provided in the geographic layout display is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	2	3	0	0	0
Group 2	2	2	0	0	0

	Drill-down information accessible from aircraft icons adds value to aircraft status data.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	1	0	0	0
Group 2	4	0	0	0	0

B.3.1.2.3 Munitions

LUG members viewed the munitions capability (including accessibility to MSC2) to be both powerful and useful; however, they perceived it as a whole to be fairly specialized—i.e., one likely to be used by only a few users who have specific needs for munitions data (e.g., Pro Supers or those with munitions expertise). Munitions experts in the group recommended the inclusion of additional capability—namely, the integration of munitions training data with the live munitions data currently provided via LOCIS, as well as the inclusion of munitions status data (FMC versus NMC). Munitions experts also identified the usefulness of a new view (with daily updates) to provide information on projected expenditures.

The following tables document subjective ratings for LOCIS munitions displays. Each table reports the number of users assigning a given rating.

	Presenting munitions data in a table format makes munitions displays				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	4	1	0	0	0
Group 2	1	2	1	0	0

	The MSC2 analysis tool available as drill-down capability from LOCIS munitions displays (*Munitions Detail* hyperlink) adds value to munitions data..				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	4	0	1	0	0
Group 2	4	0	0	0	0

	The color-coding provided in the *Availability Forecast* view is				
	1 *Meaningful*	2	3	4	5 *Not at all Meaningful*
Group 1	5	0	0	0	0
Group 2	2	2	0	0	0

B.3.1.2.4 Print Screen

LUG members believed the print screen option to be a good one. They recommended a set of appropriate default settings for each screen. For color-coded objects, LUG members identified the need for some type of redundant coding strategy (to support those using black and white printouts). LUG members also identified a need to print a report specifying status, driving discrepancy, ETIC, and JCN for all NMC aircraft, suggesting that such a printout would be useful when used with current EMOC sheets. Printouts of the Recap view would be useful during production meetings and stand ups, or a (new) view containing data on NMC aircraft.

The following tables document subjective ratings for the LOCIS print screen option. Each table reports the number of users assigning a given rating.

	The "print screen" capability is sufficient to support maintenance stand-up meetings.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	2	2	1	0	0
Group 2	1	3	0	0	0

	The "print screen" capability would provide better support for maintenance stand-up meetings than a report generator capability.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	0	2	3	0	0
Group 2	4	0	3	1	0

B.3.1.2.5 Tools

Forecasting

LUG members were extremely favorable toward the forecasting capability implemented in LOCIS. They believed the capability would be used frequently—but in different ways by different types of users. Pro supers, for example, would most likely use the forecasting capability to build various "rack and stack" lists (i.e., use it as an analysis tool). On the other hand, most senior-level managers would primarily be interested in the analysis products, using them to review or monitor current conditions. LUG members also believed the LOCIS forecasting capability would save a significant amount of time in generating aircraft rankings for different types of scenarios. (LUG members estimated that with current methods, the kind of aircraft ranking provided by LOCIS will typically require a day to build.) LUG members suggested several enhancements to the scenario settings section of the tool (e.g., changing the term "system integrity" to "system reliability", allowing users to specify multiple MDSs, and providing users a clearer indication that system integrity/munitions requirements and evaluation factor ratings are part of the scenario setup). When considering the Health of Fleet (HOF) Table, LUG members indicated that additional drill-down or rollover information accessible from System Integrity cells would be useful. Such data would be provided by tail number and WUC. Suggested drill-down data included discrepancy, corrective action, and repeat/recur. Suggested rollover information for system integrity cells was the set of "top three" write-ups.

The following tables document subjective ratings for the forecasting decision support capability implemented in LOCIS. Each table reports the number of users assigning a given rating.

	The table format lends itself well to the presentation of HOF data.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	3	2	0	0	0
Group 2	2	2	0	0	0

	Information available in the HOF ranking table is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	3	2	0	0	0
Group 2	2	2	0	0	0

	I have confidence in the validity of analysis results provided in the forecasting capability.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	1	3	1	0	0
Group 2	2	2	0	0	0

	Information provided in the Summary Report adequately describes analysis results.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	3	2	0	0	0
Group 2	2	2	0	0	0

	Entering scenario data (via the *Edit* button) is easy.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	5	0	0	0	0
Group 2	4	0	0	0	0

B.3.1.2.6 LOCIS Notifications

Alert and Warning Message Log

In assessing the Alert and Warning Message Log, LUG members identified the need for a more meaningful description of the events leading to a change in threshold status. LUG members felt the log's usefulness would be improved if it could help users gain a clearer understanding of what happened to cause status changes. Along these same lines, LUG members believed threshold drill-down information could be made more meaningful if it clearly indicated the event driving the status change (and triggering an alert or warning). In the current implementation of LOCIS, for example, when a launch sequence warning is generated and the user drills down for further details, LOCIS pushes the Launch Sequence view. However, without a "pointer" directing the user to the problematic line number, that user must spend additional time

diagnosing the problem: determining which line number has triggered the warning, locating the data for that line number, and then identifying the step(s) with late completion times.

The following tables document subjective ratings for the Alert and Warning Message Log. Each table reports the number of users assigning a given rating.

	Information provided in the Alert/Warning Message Log is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	3	2	0	0	0
Group 2	0	2	2	0	0

	Drill-down information accessible from the Alert/Warning Message Log adds value to alerts and warnings.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	3	1	1	0	0
Group 2	1	1	1	1	0

B.3.1.2.7 Threshold Settings

LUG members liked the threshold settings approach implemented in Spiral 3 (i.e., linking each threshold to an individual LOCIS view and accessing/editing threshold settings from that view). They also validated the business rules implemented for the launch sequence threshold. In discussing appropriateness of the settings currently implemented for LOCIS' launch sequence threshold, LUG members confirmed the need for users to select the launch sequence steps they wish to monitor and then specify the times at which these steps will be considered late. (The user-specified times will serve as triggers for warnings and alerts.) They also recommended that the option *All* be included in the drop-down list of line numbers and that each line number be identified with its respective organization. When considering settings for the aircraft availability threshold, LUG members confirmed a need to know the total number of aircraft associated with a selected MDS.

The following tables document subjective ratings for the threshold settings approach. Each table reports the number of users assigning a given rating.

	Setting warning (yellow) and alert (red) threshold levels is				
	1 *Easy to Understand*	2	3	4	5 *Not at all Easy to Understand*
Group 1	2	3	0	0	0
Group 2	0	3	1	0	0

	The business rules defining "red" and "yellow" levels for launch sequence thresholds are appropriate.				
	1 *Strongly Agree*	2	3	4	5 *Strongly Disagree*
Group 1	2	3	0	0	0
Group 2	2	2	0	0	0

B.3.1.2.8 Customization - Workspace Builder

LUG members believed the Workspace Builder to be a user friendly customization feature, and they found the set up process easy and simple. LUG members liked the "drag" option for resizing windows. While they also liked the right/left and up/down arrows that could be used to expand and collapse windows, LUG members preferred the more traditional "box" icons used in windows-based interfaces. LUG members indicated the difficulty of remembering the name of each view.

Appendix C – LOCIS Requirements

Number	Name	IDEF0 Node	Spiral 1	Spiral 2		Spiral 3
1	Identify User	A11	1	2	B	3
2	Identify Job Responsibility	A12	1	2	B	
3	Identify Position and User Access Restrictions	A13	1	2	B	
4	Identify Subject / Topic	A14	1	2	B	
5	Identify Default Data Elements	A151	1	2	B	
6	Identify Default Data Changed by User	A152	1	2	B	
7	Identify Placement of Data	A16	1	2	B	
8	Define Resources	A21	1	2	B	
9	Define User Thresholds	A22	1	2		
10	Define Formal Message Threshold	A231				
11	Define SITREP Threshold	A232				
12	Define Disaster Threshold	A24				
13	Establish Available A/C Threshold	A2511		2		3
14	Establish FMC Rate Threshold	A2512		2		
15	Establish PMC Rate Threshold	A2513		2		
16	Establish Utilization Rate Threshold	A2514				
17	Establish Threshold for Scheduled Maintenance Actions Canceled	A2515				
18	Establish Systems Status Threshold	A2521				
19	Establish ETIC Slips By Systems Threshold	A2522				
20	Establish Systems Reliability's Threshold	A2523				
21	Establish Abort Rate Threshold	A2524	1	2		
22	Establish Repeat/ Recur Rate Threshold	A2525	1	2		
23	Define Munitions Thresholds	A253				3
24	Define Supply Thresholds	A254	1	2		
25	Establish Threshold for Parts/Supplies for AGE	A2611				
26	Establish Threshold for Parts/Supplies Vehicles	A2612				
27	Establish Threshold for Parts/Supplies Facilities	A2613				
28	Set Minimum Number of On-Hand Gallons Threshold	A2621				
29	Set Maximum Number of Days to Obtain Resupply Threshold	A2622				
30	Set Consumption Rate Threshold	A2623				
31	Set Minimum Number of Hot Pits Threshold	A2624				
32	Set Minimum Number of Panagraphs Threshold	A2625				
33	Set Minimum Number of POL Trucks Threshold	A2626				
34	Set Minimum Number of Trained Drivers Threshold	A2627				
35	Define Transportation Threshold	A263				
36	Define AGE Threshold	A264				
37	Define Personnel Threshold	A265				
38	Define Facilities Threshold	A266				
39	Define Threshold Combinations	A27				
40	Receive Weekly Flying Schedule (Peace-Time Sortie Generation & Munitions Requirements)	A311	1	2	B	3
41	Receive ATO (War-Time Sortie Generation & Munitions Requirements)	A312				
42	Sort Requirements by Functional Area	A313				
43	Define Vehicle Consumption Standards Requirements	A321				
44	Define POL Consumption Standards	A322				
45	Define Wing Aircraft System Configuration	A323				
46	Define AGE Standards	A324				
47	Define Logistics Personnel Skills Standards	A325				
48	Project Future Events / Requirements	A331	1	2		3
49	Determine How Shortfall Can Be Rectified	A3321				
50	Determine if the Unit Can Support A Requirement	A3322	1	2	B	3

Number	Name	IDEF0 Node	Spiral 1	Spiral 2		Spiral 3
51	Identify Timing Associated With Supporting A Requirement	A3323				
52	Dispatch Current and Future Requirements to All Functional Areas	A34				
53	Adjust Mission Requirements	A35				
54	Determine Diagnostic Method	A41				
55	Collect Specified Threshold Actual Data	A421	1	2	B	3
56	Compare Actuals to Thresholds	A422	1	2	B	
57	Evaluate Combined Thresholds	A423				
58	Identify Negative Trends (Timing)	A43	1	2	B	
59	Identify NMCS Status	A4411	1	2	B	3
60	Identify PMCS, PMCM, PMCB A/C	A4412	1	2	B	3
61	Identify Available A/C Location	A4413	1	2	B	3
62	Identify A/C Configuration	A4414		2	B	
63	Identify Available Types	A4421				3
64	Identify Available Munitions Location (On-Site and Off-Site Storage, etc.)	A4422				
65	Identify Type Available and Quantity	A4423		2		3
66	Identify Available Components (On-hand or in Supply)	A4424		2		3
67	Assign/Identify Available Tail Numbers To Mission	A443				
68	Assign/Identify Available Munitions to Mission	A444				
69	Determine Shortfalls Between Task And Resources	A445				3
70	Identify NMCS/MICAP, NMCM, NMCB A/C	A4511	1	2	B	3
71	Identify A/C Location	A4512	1	2	B	3
72	Identify Scheduled Maintenance	A4513		2	B	3
73	Identify Real-Time Sortie Generations A/C Discrepancies As They Occur	A452	1	2	B	3
74	Identify A/C Scheduled for Maintenance Problems	A453				3
75	Identify Munitions Handling Equipment Problems	A454				
76	Identify Potential Beddown Location Problems	A4611				
77	Identify Site Survey Problems	A4612				
78	Identify Parking Problems	A46131				
79	Identify Re-Fueling Problems	A46132				
80	Identify ICT Problems	A46133				
81	Identify Actual Beddown Location Resource Shortfalls	A46211				
82	Identify Preliminary Buildup Action Problems	A46212				
83	Identify Essential Personnel Recall Problems	A46213				
84	Identify LIMFACs / Shortfalls	A46214				
85	Identify Deployed / Cross Country A/C, People and AGE Recall Problems	A46215				
86	Identify TPFDD Tasking Problems	A46221				
87	Identify Airlift Schedule Problems	A46222				
88	Identify War Reserve Material Problems	A4623				
89	Identify Redeployment / Reconstitution / Retrograde Problems	A4624				
90	Identify Contracting Problems	A4631				
91	Identify Communications Problems	A4632				
92	Identify Security Problems	A4633				
93	Identify Weather Problems	A4634	1			
94	Identify Civil Engineer / Airbase Operability / Disaster Preparedness Problems	A4635				
95	Identify Services Problems	A4636				
96	Identify Problems with Shift Assignments	A4641				
97	Identify Problems with Training	A4642				
98	Identify Unavailable Personnel Due To Legal/Disciplinary Actions	A46431				
99	Identify Unavailable Personnel Due To Pre-Flight Physicals	A46432				
100	Identify PRP / Clearance Problems	A46433				
101	Identify Joint Logistics System Problems	A4651				

Number	Name	IDEF0 Node	Spiral 1	Spiral 2		Spiral 3
102	Identify Vehicle Support / Maintenance Problems	A46521				
103	Identify Lean Logistics Resupply / Transportation Problems	A46522				
104	Identify Joint/Coalition Facility Problems	A46523				
105	Identify Command Activities / Structures Problems	A4653				
106	Prioritize Problem	A48	1	2	B	
107	Determine Sortie Generation Command & Control Problem Causes/Indicators	A52				
108	Identify Sources of Supply	A5311	1	2	B	
109	Identify Quantity On-Hand	A5312	1			
110	Identify Parts Arrival Time	A53131	1	2	B	3
111	Identify Mode Of Shipment	A53132				
112	Identify Location	A53133				
113	Identify Path Of Arrival	A53134				
114	Identify Date Of Arrival	A53135		2		
115	Flight Line Requisitions Part	A53141				
116	Supply Checks For Base Availability	A53142				
117	Issue Spares From Available Stock	A53143				
118	MOC Pushes Highlighted A/C Button Problem Spelled Out	A5314411				
119	LOCIS Users See Options for A/C	A5314412				
120	Pro-Super Spares Aircraft with New A/C	A5314413				
121	LOCIS Moves Original A/C into Maintenance Area	A5314414				
122	LOCIS Moves New A/C into Original Flying Line	A5314415				
123	Requisition From Depot	A531442				
124	Requisition From Lateral Unit	A531443				
125	Expedite Depot Repair Through Lean Logistics	A531444				
126	Receive/Expedite Inbound Parts Through Military/Commercial Channels	A531445				
127	Auto Indication In MOC That No Spare Receiver Is Available In Supply	A5315				
128	Identify Status Of Contracting Efforts To Support Mission	A5316				
129	Reprioritize Contracting Efforts To Fill Critical Requirements	A5317				
130	Identify Available POL	A532				
131	Identify Available AGE	A533				
132	Identify Personal Information	A53411				
133	Identify Assigned Tasks	A53412				
134	Identify Skill Level	A534131				
135	Identify Qualifications	A534132				
136	Identify Certifications	A534133				
137	Select Qualified Personnel	A53414				
138	Identify Authorized Personnel	A5342				
139	Identify Types Of Needed Facilities	A5351				
140	Identify Facilities Status	A5352				
141	Identify Facilities Alternate Uses	A5353				
142	Identify Maintenance Status Of All Assigned Equipment/Circuits	A5354				
143	Monitor Water/Waste/Power Requirements	A5355				
144	Identify Available Vehicles	A536				
145	Combine Problem Type, Timing, & Available Resources	A541				
146	Identify Alternate A/C	A5421				
147	Track Breakout And Delivery Of Tanks	A54221				
148	Track Breakout And Delivery Of Pods	A54222				
149	Track Breakout And Delivery Of Munitions	A54223				3
150	Track Reprogramming Of ECM Systems	A54224				
151	Track Uploading Of OFP Updates	A54225				
152	Load Live Munitions IAW Deployment Order	A54226				
153	Assign Mission	A542311				

Number	Name	IDEF0 Node	Spiral 1	Spiral 2		Spiral 3
154	Assign To ICT According To Munitions	A542312				
155	Check MESL	A542321				
156	Check Next Mission	A542322				
157	Decide Whether To Turn Or Repair	A542323				
158	Assign To Expediter	A542331				
159	Assign To Appropriate Repair Locations	A542332				
160	Re-Prioritize Solutions	A54234				
161	Check Availability Of Technicians To Perform Unscheduled Maintenance	A54241				
162	Check Availability Of Equipment To Support Unscheduled Maintenance	A54242				
163	Determine Per Cent Completed	A542431				
164	Determine Engine Location	A542432				
165	Move/Adjust Internal (Wing) Resources	A5425				
166	Collect Info On Wing Shortfalls	A542611				
167	Review Shortfall Information	A542612				
168	Transmit Info To Higher Headquarters	A542613				
169	Convey Problem To Other Unit	A542621				
170	Discuss Solutions	A542622				
171	Request Assistance	A542623				
172	Prioritize Solution	A543				
173	Present Problem / Solution	A544				
174	Report Munitions Arrival at Ramp	A5511				
175	Report Loads Begin	A5512				
176	Report Completed Munitions Load	A5513				
177	Report POL Status	A5514				
178	Report Pilot Show At A/C	A5515	1	2	B	3
179	Report Maintenance Actions Status	A5516	1	2	B	3
180	Report A/C Taxi	A5517	1	2	B	3
181	Report A/C Take-off	A5518	1	2	B	3
182	Report A/C In-Flight Status	A55211		2	B	3
183	Report ABDAR Status	A55212				
184	Report A/C Location	A55213	1	2	B	3
185	Report POL Trucks Dispatched To Turn Spots	A55361				
186	Report Ammo Reconciliation	A55362				
187	Report Flight Crew Debrief	A55363				
188	Report ABDAR Capability	A55364				
189	Report Land Times	A55365		2		3
190	Capture Actual Data	A55366	1	2	B	3
191	Identify Level of Effort (Quick Fix, etc.)	A561				
192	Select Solution	A562				
193	Dispense Changes to Impacted Functional Areas	A57				
			35	43	31	29
			18%	22%	16%	15%

Appendix D - Reference Documents

Document No.	CDRL No.	Title
1004240	N/A	Program Plan of Execution
1004241	N/A	Software Development Plan
1004242	N/A	Risk Plan
1004243	N/A	Data Collection Plan
1004244	N/A	Software Quality Program Plan
1004245	A001	Monthly Status Report
1004246	N/A	C/C++ Style Guide
1004247	A008	Data Accession List
1004248	N/A	Operational Architecture Specification
1004249	A015	System Requirements Specification
1004250	N/A	Java Style Guide
1004251	A006	Program Management Review Minutes Package
1004252	A006	Preliminary Design Review Minutes Package
1004253	N/A	Year 1 Functional Scenario
1004254	A004	Contract Funds Status Report
1004255	A010	Demonstration Plan
1004256	A006	Critical Design Review Minutes Package
1004257	A012	Training/Administrators Plan
1004258	A014	Software Version Description
1004259	A011	Software Product Specification
1004260	A016	Technology Transition Report
1004261	A009	Spiral 1 Final Report
1004262	N/A	Year 2 Operational Architecture Specification
1004263	A006	Spiral 2 PMR/PDR Minutes
1004264	A006	Spiral 2 CDR Minutes
1004265	A015	Spiral 2 System Requirements Specification
1004266	N/A	Block Release User's Manual
1004267	N/A	Block Release Training Guide
1004268	N/A	Spiral 3 System Document

Document No.	CDRL No.	Title
1004269	N/A	Hurlburt Living Lab Sys Admin Plan
1004270	A006	Spiral 3 PMR Minutes
1004271	A009	Spiral 2 Final Report
1004272	A006	Spiral 3 PDR Minutes
1004273	A016	Spiral 2 Technology Transition Report
1004274	A010	Spiral 2 Demonstration Plan
1004275	A014	Spiral 2 Software Version Description
1004276	A011	Spiral 2 Software Product Specification
1004277	A006	Spiral 3 CDR Minutes
1004278	A012	Spiral 3 Admin/Training Plan
1004279	A010	Spiral 3 Demonstration Plan
1007830	N/A	Spiral 3 Operational Architecture Specification
1007831	N/A	Spiral 3 Hurlburt Field Load, Installation, and Configuration
1007832	A009	Spiral 3 Final Report
1007833	A016	Spiral 3 Technology Transition Report
1007834	N/A	System Security Authorization Agreement
1007835	A014	Spiral 3 Software Version Description
1007837	A011	Spiral 3 Software Product Specification
1007838	A015	Spiral 3 System Requirements Specification

Appendix E - Measuring Situation Awareness for Logistics Command and Control - Preliminary Testing

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Table of Contents

1 Abstract

This paper describes an initial effort to measure SA in the context of logistics command and control. Logistics Control and Information Support (LOCIS) is a prototype decision aid intended to allow a maintenance supervisor to perform his/her job more quickly without any loss of SA. A literature review revealed that existing measures devised to assess SA in the context of aviation do not transfer well to command control tasks. Therefore, existing measures of SA were adapted, and then piloted in a preliminary study designed to assess the impact of LOCIS on maintenance supervisor SA. Findings indicate that LOCIS provides support for building SA in the context of two specific tasks key to the maintenance supervisor job: preparing for the Daily Aircraft Maintenance Morning meeting and planning for a deployment. A third task, providing recap information at shift change, was planned but adequate data was not collected due to technical difficulties. Although these findings are based on a very small sample of four maintainers -- and therefore of limited generalizability -- this study represents a first step toward assessing SA in command and control tasks. Recommendations for assessing SA in a full-scale field study, as well as recommendations for improving LOCIS are included in this paper.

2 Introduction

Logistics Command and Control Information Support (LOCIS) is a prototype decision aid designed to present information to maintenance supervisors in a timely and understandable format. The overall goal of this system is to allow the maintenance supervisor to accomplish his/her job more quickly without a loss of Situation Awareness (SA).

Maintenance supervisor is a generic term used in this paper to describe the people who manage and supervise logistics and maintenance for an Air Wing from the non-commissioned officer in charge or officer in charge up to the maintenance group commander. These users comprise a team that is tasked with ensuring that daily flying schedules are met, monitoring the scheduled repair of broken aircraft, planning for future deployments and TDYs, noting trends in aircraft breakage, and promoting seamless transition of information between shifts. Although each has additional responsibilities, these are the tasks LOCIS is intended to support.

LOCIS presents, in a compact and readable format, information that is currently obtained via disparate sources including various databases, support personnel, the monitoring of radio traffic, and meetings of different team members. LOCIS users are able to obtain a quick view of the flying schedule for the day using the "schedule at a glance" visualization, obtain recap information about previous flights using the "recap screen," and use the "health of the fleet forecasting tool" to identify the aircraft most suitable for a specific deployment or TDY. Additionally, information about the status of broken aircraft is available via a number of paths within LOCIS. The intent of LOCIS is to provide maintenance supervisors information critical to maintaining accurate SA in an easily accessible format that is at their fingertips.

This paper describes a pilot study conducted to assess the feasibility of measuring the impact of LOCIS on maintenance supervisor SA. Existing methods for measuring SA were developed in the context of military aviation. Not surprisingly, measures developed to assess SA in the aviation domain do not generalize directly to command and control environments, with tasks involving a longer timeline, an ill-defined mission beginning and end, and a strong monitoring component.

Due to the fact that a great deal of SA testing has dealt with actual aircraft "pilots" as subjects, from this point on this document will refer to our "pilot" study as a preliminary study (to reduce terminology confusion).

A small preliminary study was conducted in preparation for a larger scale study to assess SA in maintenance supervisors. The study was constrained by a number of factors, including a limited number of SMEs available to participate in the study, the lack of a real-time simulation, and limited time with each participant. Working within these constraints we reviewed literature about existing SA measurement techniques, developed an adapted methodology, and tested it on four experienced maintenance supervisors.

The **situation awareness history and definition** section of this paper briefly describes the history and definition of SA in aviation; contrasts the characteristics of the piloting task, the traditional area of study for SA, with the maintenance supervisor task; and briefly describes existing measures of SA. The **preliminary study section** describes the adapted methodology in the context of the preliminary study. The **lessons learned about measuring SA** section describe lessons learned with a view toward a full-scale field study assessing the impact of LOCIS on maintenance supervisor SA. The final **conclusions** section summarizes our conclusions regarding measuring SA and highlights our recommendations for improving LOCIS.

3 Situation awareness history and definition

3.1 History

The term SA came into common use in the context of World War I. In Spick's 1998, *The Ace Factor,* SA is described as, "...a combination of many things, but in essence it is the ability of the pilot to keep track of events and foresee occurrences in the fast-moving dynamic scenario of air warfare" (p. vi). Pilots have found the term to be useful in describing aspects of the fast-paced, high-risk task of piloting an aircraft as they have learned from their own experiences and from each other. Successful pilots were able to quickly perceive important environmental cues, understand their significance, and accurately predict the dynamics of the situation minutes into the future so that they could be prepared to react.

Over the years, situation awareness has proven to be powerful concept for describing the state pilots are trying to achieve. However, it wasn't until the 1980s that researchers began to emphasize SA, both in terms of basic research to understand the concept and applied research to develop improved training and system design. The past 20 years has seen an explosion in training intended to prepare pilots to achieve situation awareness in time-pressured, high-risk, and sometimes complex situations, as well as system and display design strategies aimed at aided pilots in attaining good situation awareness.

3.2 Definition

Although a widely agreed upon definition of SA has proven elusive (Dominguez, 1994; Jeannot, 2000), Endsley (1988) offers the following: "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future." Researchers do agree that three key elements of SA include: 1) perceiving relevant cues, 2) comprehending or interpreting the cues, 3) and projecting an understanding of the situation to forecast future situation events and dynamics.

However, in studying the maintenance supervisor task, it is important to take into account the concept of team SA, in addition to the individual's SA. The maintenance supervisor's SA is dependent not only on his/her own knowledge of flightline activities, but on the information shared with members of his/her team. Therefore, maintaining a shared understanding of the situation at hand is important to successful performance for each team member, especially the maintenance supervisor. Endsley (1995) specifies that team

SA consists of the SA required of each team member and the overlapping SA that occurs between and among team members, especially for coordination. Building on her definition, it follows that some members of the team need a great deal of overlapping SA for successful performance. For example, the night shift maintenance supervisor and the day shift maintenance supervisor have mechanisms in place (i.e., reports, emails, recap discussions) to ensure that they have a shared understanding of the situation. Other members of the maintenance team such as the avionics specialist and engine mechanic will have a much smaller amount of overlap in their SA because their roles and therefore their focus of attention is somewhat different (see Figure 1).

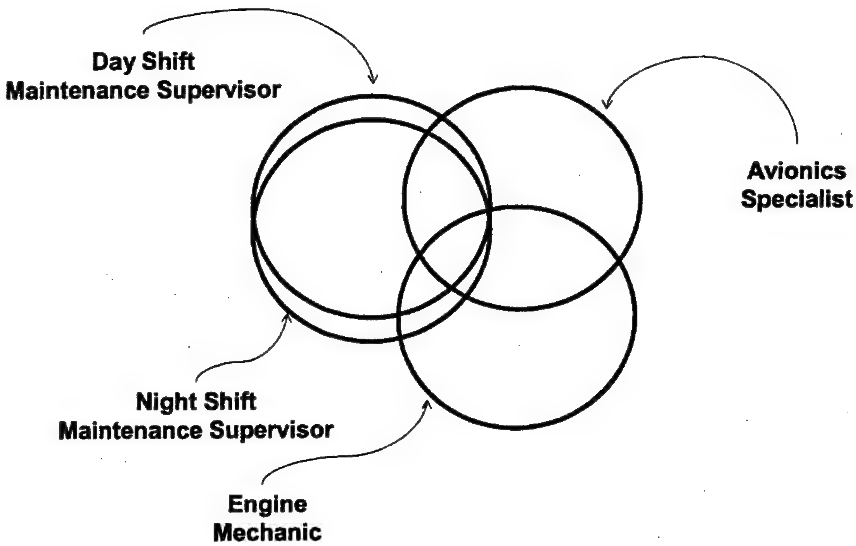

Figure 1. Notional Team Situation Awareness (Adapted from Endsley, M.R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors, 37*(1), 32-64.

3.3 Contrast: piloting and maintenance supervising

Recently, researchers have begun to generalize the construct of SA to domains quite different from aviation including anesthesiology (Gaba, Howard, and Small, 1995), air traffic control (Sollengerger & Stein, 1995), and nuclear power plant operation (Collier & Follesø, 1995) (p. 278). As we began to explore the construct of SA in the context of aircraft maintenance, some important differences between piloting and maintaining emerged.

In general, maintenance supervisors are working on a timeline much longer than that of a fighter pilot and much of their feedback does not come as a result of direct actions taken on the environment. As a result, feedback from the environment may be delayed considerably for a maintainer as compared to a pilot. Early in the morning a maintainer may schedule a specific aircraft to be fixed by 1600, in time for the afternoon flight. However, at 1500, s/he may find that additional problems were discovered during the

repairs, and therefore the aircraft may not be available to fly that afternoon. Feedback requiring deviation from a plan can take hours – or even several days – from the time the plan was conceived. Additionally, feedback from the environment may affect multiple plans being tracked by the maintenance supervisor. For example, maintenance performed on one aircraft may affect today's flying schedule as well as plans for a scheduled deployment for that aircraft in several weeks. While a pilot is often able to take an action and get direct, immediate feedback via his/her own senses, the maintenance supervisor is directing others to take action and receiving feedback via report and observation mechanisms.

For aircraft maintenance supervisors, much of the information needed is not at their fingertips; therefore they must engage in deliberate information seeking activities. Maintenance supervisors are not relying on their own perceptual skills (i.e., what is visible outside the cockpit, the sound of the engines, etc.), but on information provided by front-line maintainers. The maintenance supervisor may receive notice that a specific aircraft has a fuel leak and is scheduled for repair at 1600, but that is not enough information for him/her to do his job well. The maintenance supervisor must talk to others to find out the extent of the damage and whether repair of the aircraft at 1600 can realistically be expected. This may involve tracking down information about supply (i.e., Are the needed parts available? If not, will the parts be delivered in time? If not, does it make sense to cannibalize the parts from another jet?), information about staffing, and information about support equipment (i.e., if there are two jets with fuel problems and only one fuel barn, which jet gets precedence?). Further, if the part cannot be obtained in an acceptable time frame, the maintenance supervisor will need to collect information about other taskings scheduled for the aircraft in order to anticipate the impact this delay in repair will have on future activities.

For aircraft maintenance supervisors, SA is comprised of a more complex monitoring task than the task of a pilot. Although monitoring the environment is key to successful piloting, monitoring plays an even larger role in the maintenance supervisor task, and encompasses a large number of variable data sources. The maintenance supervisor monitors the status and activity of 24 to 72 aircraft for today, tomorrow, and as much as 90 days out when preparing for a deployment. These activities tend to be interrelated in that today's activities directly impact tomorrow's flights as well as deployments planned for the future. The maintenance supervisor must continually make trade-offs and maintain balances for each aircraft on a number of parameters. For example, if an aircraft cannot fly the scheduled mission today or tomorrow, overall flying hours for that aircraft are decreased therefore pushing back inspection schedules that are based on number of flying hours. Many of these scheduled inspections are mandatory for deployments, therefore, the deployment plan may be adversely affected by the plane's inability to fly today and tomorrow. Maintenance supervisors are constantly tracking the progress of routine maintenance, unexpected breaks, and upgrades and modifications, as well as daily flying activity for each aircraft.

For a pilot, the mission has a clearly defined beginning and end. For maintainers, tasks are much more cyclical without a distinct beginning and end. Each of the 24 to 72

aircraft for which the maintenance supervisor is responsible is constantly moving through a six-stage process: recover, repair, fuel, arm, configure, and launch. Aircraft move through these stages at different rates and many aspects of the timeline are unpredictable. Indeed, unexpected and unplanned repairs are a routine part of the maintenance world. In addition, it is not uncommon for a repair to appear to be complete, only to be discovered later that the original problem has not been completely resolved. Cycles are not limited to the six stage process for an individual aircraft; scheduled deployments are dependent on the interrelationship among aircraft and schedules. Lists of aircraft scheduled for a deployment are continually revised until the time of the deployment. In other words, the list of specific aircraft tail numbers selected for a deployment may change multiple times before the deployment. These changes are all dependent on the unpredictable nature of the processes occurring daily on the flightline. The maintenance supervisor may add and remove a tail number from the list several times depending on other maintenance activities.

3.4 Measuring SA

In this section, we briefly review established methods of measure SA. Several excellent reviews of the literature exist. See Jeannot, (2000), Perla, et al (2000), and Uhlarik & Comerford (2002) for more thorough reviews of the SA literature.

The Situation Awareness Rating Technique (SART) (Taylor, 1990) and Cognitive Compatibility – Situation Awareness Rating Technique (CC-SART) (Jeannot, 2000; Taylor, 1995) are perhaps the most well known tools for measuring SA. With these methods, study participants provide self-ratings on a set of ten generic SA constructs. The constructs are grouped into three categories: Demand on attentional resources, Supply of attentional resources, and Understanding. Ratings for all the dimensions are combined to get an overall SA value. These tools have been used successfully in the context of decision tasks by navigators and pilots (Selcon & Taylor, 1990), as well as in an air-to-ground attack simulation (Vidulich, Crabtree, & McCoy, 1993).

SART and CC-SART work best as a post-task or post real-time situation measure. Participants are asked to reflect on recent experience and make ratings for each dimension. We found this strategy less relevant for our preliminary test because the maintenance task would not be performed real-time. Even if we had had a real-time simulation, maintenance supervisors often do not get clear feedback immediately. Therefore, flaws in understanding may not be clear to an individual for some time. As a result, we determined that this type of self-rating would not be feasible for command and control tasks such as maintenance supervising which are characterized by delayed feedback and multi-hour or multi-day timelines.

The Situation Awareness – Subjective Workload Dominance (SA-SWORD) technique is based on the Analytic Hierarchy Process (Vidulich & Hughes, 1991). This method involves pairwise comparison for each experimental condition. This method was developed in the context of studies designed to assess the efficacy of two or more designs, hence the emphasis on pairwise comparisons. For our study, the lack of

parallelism between the use of LOCIS and the traditional means of performing the maintenance supervisor tasks made creating meaningful pairs impractical.

SA Rating Scales (SARS) was developed specifically to measure SA in fighter pilots (Bell & Waag, 1995; Waag & Houck, 1994). Thirty-one behavior elements were identified that are considered important for mission success. Pilots were asked to rate themselves and other pilots in terms of SA on a 6-point scale, ranging from acceptable to outstanding. For this line of research, SA was regarded as an innate ability rather than a changeable state of knowledge. Although SARS was found to be very useful for assessing SA in F-15 pilots in the context of training simulations, the definition of SA as an innate ability made application of the SARS strategy less relevant for our study.

The Situation Awareness Global Assessment Technique (SAGAT) was developed by Endsley (1988). Participates are asked to work through a simulation. At specific points, the simulation is frozen and a set of randomly selected questions is administered. All data from the simulation is removed while the participant responds to the questions. The accuracy of the participant's responses is used as a measure of SA. This technique requires a real-time simulation that can be frozen, and therefore was not feasible for our study. Furthermore, this method is best suited for a task that requires memorization as it seems likely that participants in many tasks may have accurate SA, but be unable to recite the details of the data without referring to charts or decision aids available on the job.

The Situation Present Assessment Method (SPAM) (Durso, et al., 1995) makes use of a confederate SME. Several times during the task or real-time simulation, a realistic confederate calls and asks the participant a question. Investigators measure how long it takes the participant to gather the requested information as well as the accuracy of the answer. The ability of the confederate to present him/herself as a believable coworker is critical, so that the participant is unable to discern test questions from other genuine questions asked during the task. In addition to a realistic confederate, this method requires a high-fidelity simulation and a task that allows for potential interruptions by a confederate. These requirements eliminated SPAM as a potential tool for our preliminary study.

Our strategy for leveraging previous work on SA to adapt existing methodologies for use in less dynamic tasks is described below.

4 Preliminary Study

4.1 Introduction

Given the constraints of our study, none of the well-established SA measures could be applied directly. Therefore, we went back to the definition of SA supplied by Endsley (1988) and developed a strategy that would be feasible for measuring SA in a command and control task characterized by a complex monitoring component, a timeline that is hours or days rather than minutes, and feedback which is often neither direct nor immediate.

In keeping with the basic principles of SA measurement (Endsley & Garland, 2000), We determined that we wanted to measure whether participants in our study were:

A) noticing the same cues,
B) understanding the cues in the same way, and
C) forecasting events in the future in a similar manner.

Although a realistic prototype of the LOCIS decision support tool was available, technical limitations prevented us from using real-time data in this preliminary study. In addition to technical limitations, it would not have been feasible to conduct the study in real time, as SA unfolds over the course of an 8-hour shift (at a minimum) for maintenance supervisors. Therefore, we worked with software developers to enter data that would represent the state of the Aircraft Maintenance Unit (AMU) at three different points in the day. A scenario was built around each of those points. Each scenario focused on a specific task key to the maintenance supervisor's job. In order to examine situations in which SA spans more than an 8-hour shift, one scenario was designed in which the maintenance supervisor was asked to plan an activity that would not occur for four weeks.

4.2 Methods

Four people from the maintenance community participated in this preliminary study: one Technical Sergeant, two Senior Master Sergeants, and one Chief Master Sergeant. Each of the four Non Commissioned Officers had over 20 years experience in Air Force aircraft maintenance. One of the participants was from the Air Force Special Operations Command (AFSOC), and the other three were from Air Combat Command (ACC). All four participants are currently working in maintenance management positions.

The maintainers in this study each participated in a two-hour session, beginning with introductions followed by SA testing. SA testing consisted of the presentation of a scenario in which the participant was asked to complete a task. During the task, participants were asked to think aloud, highlighting information they were seeking and the significance of the information. After each task, a short interview with questions directed at eliciting cues noticed, an understanding of the situation, and forecasting information was administered.

Each of the three scenarios targeted a task in which SA in particularly important for successful job performance by the maintenance supervisor. Each is described below.

Scenario 1: morning meeting preparation. The first scenario revolved around preparation for the Daily Aircraft Maintenance Morning meeting. Each morning the maintenance supervisor meets with production superintendents and other sortie production supervisors to update the rest of the team on the current situation and goals for the day, assign tasks, and obtain information to fill out his/her SA. Morning meeting preparation includes assessing the status of the aircraft,

reviewing the schedule for the day, prioritizing actions for the day, and identifying information needs (i.e., the need to talk to the maintenance officer to find out why one of those broken jets has not been cannibalized for parts.). Participants were asked to prepare for the morning meeting using LOCIS.

Scenario 2: deployment planning. In the second scenario, participants were informed that orders had come down asking them to prepare for a four-week deployment, to take place four weeks from today. They were provided information about the number of aircraft required, the expected number of sorties, estimated flight time to location, munitions requirements, etc. Using this information and interacting with LOCIS, participants were asked to develop a "rack and stack," a document identifying the aircraft most suitable for the deployment and listing all the maintenance activities that need to take place on each aircraft before the deployment.

Scenario 3: shift change recap. The last scenario moved forward in time to the end of the day. Participants were informed that the swing shift maintenance supervisor was new to the unit. Therefore, the participant would want to conduct a very thorough recap and highlight important issues that might be overlooked or might be potentially problematic for someone new to the unit. Participants were asked to use LOCIS to pull together the information they would want to pass along to the swing shift replacement.

After being introduced to each scenario, participants were asked to think aloud as they interacted with LOCIS if that was comfortable to them, and to inform the interviewer when they had completed the task. Because participants had received limited training on LOCIS, they were encouraged to inform the interviewer if they were looking for information that they could not remember how to access in LOCIS. All participants were able to complete each task in less than 20 minutes.

After completing each task, participants were asked a series of questions aimed at unpacking their situation awareness. The question series was designed to elicit information regarding what participants noticed and understood, and how they would forecast the situation into the future. These questions included:

- What are the important things you want to discuss in the morning meeting/communicate to your swing shift replacement? What are the things on the rack and stack you are paying particular attention to?
- What 3 things are you most worried about?
- What are you priorities at this point in time?
- What information do you need that you don't have?
- What will you do next?
- What problems are you anticipating?

A second set of questions focused on how the tasks included in the scenarios (i.e., morning meeting, deployment planning, recap) happen currently, without the use of

LOCIS. This second set of questions was aimed at helping us understand how good SA is achieved in the context of current operations without LOCIS. These questions included:

- When was the last time you led a morning meeting/created a rack and stack/had a recap discussion at shift change?
- Can you walk me through how you prepared?
- Was the incident you just described pretty typical?
- Is there information you have access to in your unit that is not available on LOCIS?
- Is there information in LOCIS that you do not have easy access to in your unit?

4.3 Analysis

Data from each scenario was analyzed to explore whether participants noticed elements that scenario designers intended them to, understood the significance of the data, and forecasted similar outcomes in the context of completing each task.

Analysis for this preliminary study focused on examining these SA components in two ways. First, specific cues were included in each scenario. Our intent was to determine whether participants noted those specific cues, understood them in the way intended, and forecasted them as expected. Information gathered from maintenance supervisors was compared with these expected results to validate the scenario as well as to affirm SA provided by LOCIS.

Second, information gathered from the four maintenance supervisors was compared and contrasted to more fully understand the SA issues and implications associated with the scenario. Three researchers each took the data from one of the three scenarios to be analyzed in depth. Each researcher restructured the interview notes to facilitate observation across participant responses for an individual task (i.e., morning meeting, deployment planning, or end-of-shift recap). Each researcher examined the data to answer the following five questions, working from a shared analysis guide.

1. Did all four participants notice the same things? What did they notice? Provide examples.
2. Did all four participants interpret information in the same way? How did they understand the situation? Provide examples.
3. Did all four participants predict future events similarly? What did they forecast? Provide examples.
4. In what ways did LOCIS support SA for this task?
5. Did LOCIS obstruct or hinder SA in any way? If yes, do we have any candidate solutions?

After independently analyzing the data, the three researchers met with two SMES who had not participated in the study to calibrate and discuss the findings. In addition, lessons learned and strategies for improving this method of measuring SA were discussed.

4.4 Findings

4.4.1 Scenario 1: morning meeting preparation

4.4.1.1 SA findings

Each participant in our preliminary study quickly established accurate SA during the first scenario, noting the important elements designed into the scenario and understanding the implications of these elements for meeting the day's flying schedule. All participants noticed key elements of the morning meeting preparation scenario including a broken flyer and a broken spare (backup aircraft). All four participants understood that this situation was risky in that if anything else broke before the first flight, they would not be able to make all the scheduled sorties. With regards to forecasting, the three participants with the most relevant work experience all suggested proactive strategies, including making phone calls and providing additional direction to other team members to ensure that every effort was made to fix the broken aircraft, and contacting operations to discuss the prioritization of flights in the event that not enough aircraft would be available to meet the schedule.

There was more variability when it came to the level of detail at which participants investigated the larger issues described above. Some participants articulated more details they noticed, such as "none of the flyers are MICAP for parts"[1] or "two aircraft are off station." Some noted flaws in the scenario, such as "A8521 is PMCS[2], but should be NMCS[3] because it has 1A MICAP" or "this aircraft has a weight and balance inspection, but it is red – should not be NMC for scheduled inspection."

Furthermore, some expanded on their understanding of the situation beyond the key elements related to make the day's flying schedule. Some interpreted the fact that there were three aircraft broken for parts as an indicator that something was wrong – or that the situation required additional investigation. Generally, when a number of jets are missing parts, common practice is to cannibalized one jet to fix the others until the parts on order are received. The fact that this had not happened was a red flag to some. Some noticed that tail numbers had been swapped the day before and interpreted that to mean that a spare was flown. This was considered another area for further investigation. Participants were curious about the reason for the tail swap, as that might have implications for the future performance of the jet that was not flown.

It is not clear whether the variability in the level of detail is reflective of variability in SA, or whether this is an artifact of our methods. In future studies it may make sense to ask more directed questions to assess whether participants are noticing, understanding, and forecasting important elements of the scenario.

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[1] MICAP refers to mission essential parts that are not readily available
[2] PMCS refers to aircraft that are only partially mission capable, they can be flown but will not be able to complete the mission as defined.
[3] NMCS refers to aircraft that are not mission capable and cannot be flown

4.4.1.2 LOCIS findings

In terms of supporting SA, our data indicate that LOCIS will provide valuable information to maintenance supervisors in building accurate SA as they prepare for the morning meeting. The *Status at a Glance* feature provides a concise overview and calls the user's attention to broken aircraft, particularly those scheduled to fly. All the participants in our study were able to quickly identify which aircraft were scheduled to be flown, the broken flyer, the broken spare, and other broken aircraft. It was immediately clear to all participants that it would be a challenge to meet the day's flying schedule.

This information would traditionally be available via discussion with the maintenance supervisor from the previous shift and/or a review of emails and other documents created on the previous shift. The fact that LOCIS is able to provide this same information real time by pulling information from existing databases represents a significant savings in labor as the *Status at a glance* eliminates the need for other personnel to compile, integrate, and document this information.

Participants were also able to fill out their SA by obtaining detailed information about the status of each aircraft. Participants used a number of different routes through the software to obtain information about the reason each broken jet was not available, which were waiting for parts, which parts deliveries were overdue, etc. There were also able to use the recap data found in LOCIS to obtain information about the status and history of specific jets. LOCIS also provided information about inspections that were scheduled for the current day, as well as the rest of the week to aid in forecasting.

Although LOCIS in its current form provided an impressive tool for building SA, this preliminary study did highlight a few types of information maintenance supervisors require that were not found in the LOCIS prototype. Perhaps most importantly, maintenance supervisors reported that they rely on a printout of all broken aircraft and information about the status of each (reason for break, scheduled repairs, etc.) The printout is carried to meetings throughout the day and updated by hand. Maintenance supervisors rely on this printout to maintain up-to-the minute, accurate SA throughout the day when they are away from the computer. It will not be enough for LOCIS to provide accurate SA when the user is at the computer. Key printouts or mobile computing displays showing status information must be available, as a large percentage of the maintenance supervisor's day is spent away from the computer.

Other information needs reported by study participants include the flying schedule for tomorrow. Although the capability to display the flying schedule for the following day is built into LOCIS in the *schedule* screen, the data was not available in the prototype used for this study. It is important to note, however, that participants indicated that they would like to have the flying schedule for tomorrow available in the *status at a glance* format in addition to the *schedule* format. It may be fruitful to investigate the feasibility of incorporating future flying schedules into the *status at a glance* format.

Finally, participants noted that they could not obtain information about shipping status, the reason for a deviation, or landing discrepancies on LOCIS. Each of these is important to the maintenance supervisor in building SA. However, it may not be feasible to include this type of data in LOCIS. It may make sense for maintenance supervisors to continue to rely on direct access to existing data sources (i.e., MASS, CFRS) for this type of information.

4.4.2 Scenario 2: deployment planning

4.4.2.1 SA findings

Participants were able to find the needed information to build accurate SA in the deployment planning task presented in scenario 2.

Currently, in building SA during deployment planning, maintenance supervisors review a matrix, termed a rack and stack, created by Plans and Schedules. The rack and stack displays jets selected for the deployment in one column. Information about scheduled activities and status for each aircraft fill out the rest of the columns in the matrix. The rack and stack is the primary tool used over time to plan and re-plan a deployment.

In LOCIS, the user enters specifications for a planned deployment in the *health of the fleet forecasting tool*, and LOCIS generates a rack and stack.

Using the LOCIS *health of the fleet forecasting tool*, all of the participants noted that LOCIS recommended a number of aircraft that were scheduled for PDM (major scheduled maintenance off-site). Each participant explained that a scheduled PDM would eliminate that jet from the planned deployment and they quickly and easily removed that jet from the rack and stack. Although this suggests that the LOCIS recommendations were not accepted carte blanche by participants, it also indicates that participants were engaged in the scenario and had sufficient SA to quickly notice flaws in the recommended plan and rapidly make the necessary adjustments.

Other important data that was noted by all participants include HPO, which is another strong determinant as to whether a specific aircraft will be available for a deployment. All agreed that an aircraft generally cannot undergo phase inspection while deployed, but that some schedule and flying manipulations could be made so that the aircraft could have the inspection before or after the deployment.

Participants noticed TCTOs (time sensitive system upgrades) scheduled. They also identified inspections that require grounding such as 18-month gun inspections and weight and balance inspections. Inspections such as egress final and parachute are more flexible and do not result in grounding.

In addition to noticing most of the same things and interpreting the information in a consistent manner, participants forecasted the situation similarly. All indicated that situation seemed challenging but that they were highly confident that they would be able

to make the deployment. This is typical of maintenance supervisor's attitudes, they harness resources and make adjustments to meet the mission need – no matter how challenging the tasks involved with meeting the goal. In this context, participants had the awareness to note that the scenario's PDM schedule did not accurately reflect PDM schedules in the real world. They were confident that over the course of four weeks, they would be able to work out any problems with the schedules to meet the deployment needs.

4.4.2.2 LOCIS findings

The *health of the fleet forecasting tool* in LOCIS supported SA for the maintenance supervisor working on the deployment scenario. The calendar format allowed the participants to scan the computer generated recommendations, as well as key information associated with each jet. Recommendations are presented in a prioritized list, so participants were able to see which aircraft were rated highest by the *forecasting tool* as well as those that received lower ratings. Furthermore, the presentation format allowed the participants to assess each aircraft's suitability without relying completely on the computer recommendations. Information required to assess each jet's suitability for the deployment includes Program Depot Maintenance (PDM) status (a scheduled activity that cannot be changed); flying time; inspection status, including FSL and In Flight Refueling (IFR); Time Critical Technical Order (TCTO) status; and schedule of HPOs (Hourly Post Operations) and dates due.

We observed participants examine the recommendations generated by LOCIS, and tweak the rack and stack based on experience and individual judgment. Observation and interview data indicate that users found the LOCIS tool to be valuable, the automatically generated rack and stack to be a logical starting place, and that the data displayed provided maintenance supervisors the information needed to make important judgments based on their own experience.

We anticipate that LOCIS will represent considerable time savings for deployment planning, while maintaining a high level of SA for the maintenance supervisor. Participants reported that it currently takes a half-day for Plans and Schedules to gather information from the CAMS terminal, and a day to manually compile the information for the rack and stack. It is expected that, using LOCIS, the maintenance supervisor will be able to complete this task in less than an hour and then will be able to quickly and easily revise the rack and stack throughout the period leading up to the deployment. This capability is currently unavailable to the maintenance supervisor without LOCIS.

In addition, some information that was previously available only in anecdotal form, is displayed in LOCIS using historical data to provide a more accurate picture. For example, an aircraft may have a reputation of being a "hangar queen" because it is prone to breaking. Maintenance supervisors take trends in aircraft breakage into account when planning for a deployment, but currently have to rely on assimilating data from various sources and on memory and judgment for this type of information. LOCIS provides systems integrity data (Low Integrity) that is based on assimilating the actual breakage

history for each specific aircraft. This capability was perceived by participants as extremely valuable.

One participant reported that having Hourly Post Operations (HPO) Difference data available numerically in LOCIS, rather than graphically as it is currently provided would help him in making confident forecasts during planning. HPO Difference data is one measure of how many hours an aircraft can fly before it must go into a phased inspection, and therefore has significant impact on deployment planning.

Participants noted several areas in which the *health of the fleet forecasting* tool could be improved. Specifically, Engine Time changes are not displayed on the *rack and stack* screen; yet this is important information used in deployment planning for many aircraft. One participant noted that there are some aircraft-specific inspections that he would like to have available on the *rack and stack* screen. Another participant comment referred to the length of time to complete certain types of inspections as valuable information in deployment planning.

One participant suggested that LOCIS should identify individual aircraft as potential deployers on status display screens (e.g., the at-a-glance screens), so there is shared understanding of which aircraft are targeted for the planned deployment activity. Others commented on the need for information regarding what parts have been loaded on pallets and which parts are available for palleting. There was also a suggestion that LOCIS should provide more information regarding which systems are keeping the Low Integrity scores down.

4.4.3 <u>Scenario 3: shift change recap</u>

4.4.3.1 SA findings

Due to technically difficulties, data regarding the flying schedule for the following day's flying schedule was not available in the LOCIS prototype used in this study. As a result, participants were not able to build adequate SA for the shift change recap scenario. Typically, the maintenance supervisor examines the following day's flying schedule along with the current status of the jets in the unit in order to recap the events of the day and highlight priorities for the maintenance supervisor on the next shift. The limitations in the data contained in the prototype used in this study made this impossible.

4.4.3.2 LOCIS findings

In spite of the difficulties in assessing the impact of LOCIS on the maintenance supervisor's SA in the shift change recap task, we were able to elicit from participants about the types of information they would like to have that are not currently available in LOCIS.

In order to support SA for the end-of-day recap, LOCIS must provide future flying schedule's (i.e., the schedule for the week) in addition to current status. Specifically,

participants reported a need for real-time information in the *recap* screen. Knowledge of the status of each jet after each sortie is key to having up-to-the minute SA. In addition, as mentioned in the context of scenario 2, it may be useful to depict tomorrow's flying schedule in the *status at a glance* format, in addition to the *schedule* screen.

It would also be useful to provide more information about scheduled maintenance and the current status of maintenance. Participants referred to the "checkerboard" format they currently use as an invaluable tool. It may be possible for future versions of LOCIS to pull data from the CAMS 380 screen to create a checkerboard in a format familiar to maintenance supervisors, depicting more detailed information about the scheduled maintenance. Some participants also suggested that highlighting the jet that has been cannibalized to repair others (i.e., the CANN jet) would be helpful.

5 Lessons Learned about Measuring SA

This initial attempt to assess SA in a command and control task has highlighted many important issues to be considered in future, larger-scale studies. As this preliminary study was conducted in preparation for a larger study to assess the impact of a fielded version of LOCIS at a working AMU, lessons learned will be discussed in that context. It will be important to frame the full-scale SA field evaluation of LOCIS, realistically considering the type of data that it is possible to collect and the context in which it should be interpreted. Planning the field study will require a great deal of upfront preparation to ensure that scenarios presented to the maintenance supervisor are robust enough to gather meaningful SA data. This is true whether the scenario is simulated or actual. Additionally, the evaluation must use methods that provide meaningful, verifiable SA data elements. The lessons learned, as highlighted in the paragraphs below, are intended to provide insight as to how this type of investigation might be successfully carried out in a full-scale SA field evaluation of LOCIS.

5.1 Framing a field study

Maintenance supervisors are highly efficient logisticians working in a complex, demanding environment. The risks associated with unsuccessful performance are potentially life threatening; therefore, motivation is very high. Maintenance supervisors have developed tools and techniques necessary to provide them with superior SA. The problem with these tools and techniques is that they are very time consuming and they vary from one base to another. If maintenance supervisors deploy to a different site, they need to learn new tools and techniques to successfully perform their jobs. Standardized tools and techniques are needed, and LOCIS provides this opportunity for standardization. Given this frame of reference, the success of LOCIS in an SA evaluation should focus on assurance of maintained good SA, not on improving SA. That is, maintenance supervisors already have superior SA; therefore, a standardized tool like LOCIS should assist in maintaining that excellent SA while significantly reducing information gathering time associated with current SA tools and techniques.

In addition, the full-scale field study will allow future data collection to incorporate the concept of team SA as a means to more effectively measure SA in the maintenance supervisor task. Data collection methods should take advantage of team SA to determine common cues, understanding of the cues, and forecasting of future events. For example, shift changes between first and second shift maintenance supervisors could provide extremely useful opportunities to assess the value of LOCIS in terms of providing all the necessary SA elements for successful job performance. This type of evaluation would compare 2nd shift maintenance supervisor SA when using LOCIS and when using common tools and techniques for information gathering. Again, the focus would be on assuring that LOCIS provides no reduction in SA, but does provide significant savings in terms of time spent collecting, integrating and disseminating information.

5.2 Scenario selection/creation

The primary advantage of simulated scenarios is that they allow the investigators to control aspects of the study. The same scenario can be presented to multiple subject matter experts (SMEs) for comparison. It is possible to build in specific, difficult elements to evaluate the system's ability to support users in challenging contexts. Investigators can specify a time-frame for the data collection and ask SMEs to schedule time for participation.

However, if pre-built scenarios are used for the field study, it will be important to ensure that dependencies among planned tasks are robust. Scenarios must reflect the dependencies among planned activities. In the preliminary study, the three scenarios used were relatively independent, which in some ways simplified the maintenance task and made for a cleaner analysis. We believe this artificiality limited our ability to realistically assess important components of SA for the maintenance supervisor. Because of this, we would recommend using more complex scenarios with greater interdependencies in future studies.

Similarly, if actual operating environments are used, it will be important to ensure that dependencies among planned tasks are emphasized in data collection. The primary advantage of using the actual operating environment is that the real-world setting adds a level of credibility to findings that cannot be attained with simulated scenarios. Collecting data as maintenance supervisors go about their jobs eliminates the difficulty involved in creating complex, realistic scenarios complete with interdependencies and the important artifacts associated with the maintenance supervisor's job (i.e., email, phone calls, radio traffic). However, collecting data in the operational environment is not a trivial endeavor. Investigators must be careful not to interfere with maintenance operations, and be willing to abandon data collection if unexpected events occur that require participants' full attention. Furthermore, it is not possible to schedule challenging, interdependent tasks in the real world. Investigators may be required to observe operations for a period of time before appropriate scenarios that challenge SA arise.

If possible, we recommend the use of a combination of simulated and real-world scenarios for the full-scale LOCIS field study. Regardless of whether a combination is used, or one approach is chosen over the other due to practical constraints, scenarios -- whether pre-built or actual -- need to include interdependent complexities to acquire full comprehension of the SA elements being considered by the maintenance supervisor.

5.3 Tailoring SA measurement tools

We found this approach of measuring, whether participants in our study were

A) noticing the same cues,
B) understanding the cues in the same way, and
C) forecasting events in the future in a similar manner,

to be effective. Of course, finding effective means to uncover what participants are noticing, understanding, and forecasting as they perform various tasks is the most challenging part of measuring SA. We found participants to be surprisingly comfortable with the think aloud during the simulation scenarios used in this preliminary study. Explaining what information they were noticing, what information they were seeking, and what meaning it had for them did not seem to represent a significant distraction from the task. Using the think aloud in combination with direct follow-up questions allowed participants to elaborate on things noted during the task immediately following completion. We would recommend this combination of data collection methods for future studies in which simulated scenarios are used.

However, if data is collected in the operational environment, think aloud techniques may be too intrusive. In a real-world setting, investigators will likely rely on observation of the maintenance supervisor, combined with follow-up interviews. Although this represents a greater reliance on the participants' memory of what was noticed and understood (and therefore an increased likelihood of memory error), interviews conducted immediately following the observation sessions will minimize memory degradation.

In terms of data analysis, the preliminary study strategy of using qualitative analysis methods to assess whether participants notice and understand the significance of specific elements built into a simulated scenario proved useful. We would recommend this approach in the future, if simulated scenarios are used.

However, an even stronger argument for the effectiveness of LOCIS in supporting SA could be made if data from the operational environment could be used to compare the SA of maintenance supervisors using LOCIS with that of maintenance supervisors relying on traditional means of building SA. Similar analysis methods would be used. This type of direct comparison will likely be difficult to arrange, but should be a goal as the study plan is created.

Finally, we recommend investigating the use of team SA as a means to assess SA in the field study. As described earlier in this paper, we would expect maintenance supervisors working different shifts to have very similar SA. Given the difficulty in establishing a ground truth SA with which to compare participant responses, comparing responses from team members expected to have shared SA may prove to be a valuable measure.

6 Conclusions

6.1 Measuring SA

The job of the maintenance supervisor has more in common with tasks such as command and control that involve monitoring over a longer timeline, than with piloting. The concept of situation awareness is instantiated quite differently in these domains and therefore requires different strategies for measurement. This preliminary test represents an initial step toward tailoring existing SA measurement techniques for use in command and control tasks.

In this preliminary study, we were successfully able to collect SA data from experienced maintenance supervisors interacting with LOCIS in the context of simulated scenarios. Data analysis revealed that, in two of the three scenarios, participants independently noticed the same key elements, developed a common understanding of the situation, and generated similar forecasts. Technical difficulties precluded the collection of this type of data for the third scenario.

The preliminary study highlighted important issues to be considered in the design of the LOCIS field study. These include:

- The maintenance community has evolved a set of processes and tools that allow maintenance supervisors to quickly obtain up-to-the-minute, superior SA. The LOCIS field study should aim to show that LOCIS provides added efficiency, without reducing SA. It is unrealistic to expect that the use of LOCIS will increase SA.
- If possible, a combination of data from simulated scenarios and data from actual operating environments should be collected.
- Regardless of whether simulated scenario, actual operation environments, or a combination of the two are used, it will be important to ensure that dependencies among planned tasks are emphasized.
- The combination of the think aloud techniques and direct questions followed by qualitative data analysis should continue to be refined for the field study.
- The full-scale field study should take advantage of aspects of team SA as an additional means to assess the impact of LOCIS on SA.

6.2 Recommendations for LOCIS

Data from this small, preliminary study indicate that LOCIS successfully supports the development of accurate SA in two tasks key to the maintenance supervisor job.

Specifically, in preparing for the Daily Aircraft Maintenance Morning meeting, participants were able to quickly obtain a high level overview of the status of the unit and gather detailed data about the status of specific jets, as needed. In the context of preparing for a deployment, participants were able to use the *health of the fleet forecasting tool* to obtain information about the status and planned activities for each jet in the unit. Furthermore, they were able to use this tool to consider different options, and the implications of various courses of action. These sorts of cognitive activities are key to building and maintaining accurate SA. Although our initial data plan included an assessment of the impact of LOCIS on the maintenance supervisor's ability to build accurate SA in the context of an end-of-day recap at shift change, we were not able to collect this data due to technical difficulties.

This preliminary study also revealed a set of suggested improvements to LOCIS. These include:

- Tomorrow's flying schedule. Participants report that they are always thinking at least a day ahead. Displaying the following day's flying schedule in the *status at a glance* format would be very helpful. A second solution suggested the addition of an identifier to the current *status at a glance* screen for jets that are scheduled to fly the following day.
- Aircraft summary screen. Participants emphasized the fact that much of the day they are away from their desks and their computers. They would like to have a printout that details all the broken aircraft, the driving discrepancy for each, and the corresponding ETIC.
- Real-time recap. It is not enough to provide recap information for the previous day. Participants indicated that they need to know after each flight: landing codes for each jet, deviations, plus the reason for each deviation.
- Scheduled maintenance. The existing scheduled maintenance information could be improved to support SA. Users would like to see a screen formatted in manner similar to the "checkerboard" they currently use. This screen would display the maintenance that has been scheduled for the entire week.

The preliminary study summarized in this report represents an important step forward in assessing SA in command and control tasks. The preliminary study also elicited important information regarding the value of LOCIS in supporting SA for maintenance supervisors, and suggestions for improving LOCIS. We anticipate that the full-scale field study will allow us to continue to refine our methods, and that it will provide a solid understanding of the impact LOCIS has on the maintenance supervisors ability to build and maintain accurate SA.

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